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NOVEMBER, 1928

SCHOOL SCIENCE AND MATHEMATICS

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EDITOR
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T. O. CANTWELL
BUSINESS MGR.
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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXVIII No. 8 NOVEMBER, 1928 WHOLE NO. 244

THE ADDED YEARS.*

BY ELLIOT R. DOWNING,
The University of Chicago.

One of the striking results of the scientific advance in recent years has been the marked increase in the average length of life. In 1789 the average in our country was twenty-eight years; at present it is fifty-eight years.

I am submitting in the charts below a number of tables that will show the decline in the death rate in several of the diseases that have been dreaded scourges in times past.

Certainly at this Thanksgiving time it is eminently fitting that we gratefully remember the work of the great scientists who have contributed to this increase in our expectation of life. It is my purpose tonight to briefly present the career of that man who stands pre-eminently conspicuous in the discovery of the causes and in the prevention of disease. I refer to Louis Pasteur, who was not only a great scientist but a great man and who has been voted by the French nation their best beloved citizen.

In thus outlining the career of Louis Pasteur, I submit the material as the type of subject matter which may be used to develop in pupils or strengthen in them certain desirable emotionalized standards, ideals of perseverance and of self-sacrificing devotion to the interests of humanity. The history of science is replete with instances of such devotion. The science teacher who fails to present these heroic lives to his pupils in an appealing way is missing the opportunity to establish ideals more profoundly influential in their lives than most of the factual material that science imparts.

*An address delivered at the meeting of the Central Association of Science and Mathematics Teachers at Detroit, November 25, 1927.

Louis Pasteur was but three generations removed from serfdom. His great grandfather, Claud Étienne Pasteur, was freed from his condition as a serf of the soil and became a tanner at

DEATH RATE FROM DIPHTHERIA PER 100,000 OF POPULATION IN CHICAGO.

1867	79.1		1898	43.7	
1868	77.4		1899	56.4	
1869	91.8		1900	49.5	
1870	139.3		1901	29.4	
1871	73.6		1902	34.8	
1872	97.2		1903	34.4	
1873	62.1		1904	21.5	
1874	44.0		1905	22.2	
1875	67.2		1906	27.7	
1876	184.5		1907	27.1	
1877	135.8		1908	26.5	
1878	120.2		1909	31.7	
1879	196.9		1910	37.4	
1880	290.7		*1911*	39.1	Schick test
1881	186.9		1912	40.9	
1882	134.3		*1913*	40.6	Toxin-antitoxin
1883	140.9	Klebs discovers	1914	31.9	treatment
1884	143.7	bacterium	1915	27.7	
1885	152.2		1916	31.5	
1886	185.2		1917	48.2	
1887	185.9		1918	27.7	
1888	161.6	Death due to toxin	1919	22.9	
1889	161.4	Yerbin & Roux	1920	23.1	
1890	114.7		1921	24.5	
1891	118.2	Von Behring used	1922	20.1	
1892	129.0	antitoxin on	1923	19.8	
1893	117.1	children	1924	12.6	
1894	107.4	Roux used antitoxin	1925	8.0	
1895	120.1	from horse			
1896	76.2	Antitoxin first used in			
1897	57.9	Chicago			

LONDON DEATHS FROM SMALLPOX PER 100,000.

1660-1679	417	1850-1860	25.
1728-1757	426	1861-1870	16.
1771-1780	502	1871-1880	23.4
1801-1810	204	1881-1890	4.5
1831-1835	83	1891-1895	2.0

SWEDEN	Highest Year	rate	Lowest Year	rate	Average
Before vaccination 1774-1880	1779	722.7	1786	31.1	200.8
Vaccination permitted 1801-1815	1801	257.0	1814	12.1	63.1
Vaccination compulsory	1875	93.5	1846	0.05	17.3

				Percent of cases fatal among *vaccinated* under 10 yrs.		*unvaccinated* over 10 yrs.	
		Cases	Deaths				
Sheffield	1887-8	4677	456	1.7	5.1	43.9	54.2
Dewsbury	1891-2	1012	110	2.2	2.3	32.1	18.7
Leicester	1892-3	357	21	0.	1.0	14.0	7.8
Warrington	1892-3	661	62	6.	6.4	67.5	33.3
London	1892-3	2353	182	0.	2.3	26.7	0.9
Gloucester	1895-6	1979	434	3.8	10.0	41.0	9.7

Salins. His son, Jean Henri, and his grandson, Jean Joseph, both continued in the same trade.

Jean Joseph, who was Louis Pasteur's father was conscripted in 1811 for the Napoleonic wars and served in the Third Regiment of the Line. This regiment was noted as the bravest of the brave. Jean Joseph Pasteur was promoted repeatedly and left the service a sergeant-major and a Chevalier of the Legion of Honor. He returned to his trade as a tanner, but unsuccessful at the old home town, he moved to Dôle.

Here at Dôle on the 27th of December, 1822, Louis Pasteur was born. The tanner's business did not prosper, however, at Dôle so the family again moved to Marnoz and shortly thereafter to Arbois. Here among the foothills of the Alps, Louis Pasteur spent his boyhood attending the primary school and the secondary school or college. Louis was a faithful, though not brilliant, student; he was known among his boy friends as "Louis

PERCENTAGE OF VACCINATED AND UNVACCINATED PERSONS LIVING IN HOUSES WHERE SMALLPOX BROKE OUT AND WHO CAUGHT THE DISEASE.

	Vaccinated		Unvaccinated	
	Under 10	Over 10	Under 10	Over 10
Sheffield	7.9	28.3	67.6	53.6
Dewsberry	10.2	27.7	50.8	53.4
Leicester	2.5	22.2	35.3	47.6
Warrington	4.4	29.9	54.5	57.6
Gloucester	8.8	32.2	46.3	50.0

TABLE SHOWING THE DEATHS FROM YELLOW FEVER FOR A PERIOD OF YEARS IN HAVANA.

Year	Deaths	Year	Deaths	Year	Deaths
1891	356	1897	858	1903	0
1892	357	1898	138	1904	0
1893	496	1899	103	1905	2
1894	382	1900	310	1906	12
1895	553	1901	18	1907	5
1896	1282	1902	0	1908	1

DEATH RATE FROM MALARIA.

	1900–1904	1910–1914
Richmond, Va.	20.2	1.8
Wilmington, N. C.	222.9	40.3
Charleston, S. C.	62.4	30.9
Savannah, Ga.	132.3	78.6
Jacksonville, Fla.	170.6	34.0
Key West, Fla.	32.5	2.0
Havana, Cuba	49.0	2.4
Rio de Janeiro, Brazil	152.9	20.7
Manilla, Phill. Islands	98.4	20.6
Calcutta, India	676.5	291.8
Rome, Italy	16.6	8.9
Hong Kong, China (British)	126.5	83.4
Colombo, Ceylon	244.4	37.0

the Artist" and there still exist some of the sketches he made in these early days, one of his mother, another of his father, one of the mayor of the town and a caricature of one of his teachers. Fortunately, however, he came in contact at the college in Arbois with a man who fired him with enthusiasm to become a teacher. This also was his father's ambition for him. So he studied with renewed diligence to prepare himself for entrance at the École Normale in Paris.

At sixteen years of age, he left home and went to Paris to enter a preparatory school. He was so desperately homesick for the familiar smell of the tanyard and for the dear ones he had left behind that his father went to Paris and brought him back to Arbois. Louis then went to the nearby college at Besançon. Here he began to discover his interest in science and when in 1840 he received his Bachelor of Letters, he was retained as assistant tutor in mathematics and physics. After a year's study at Dijon, he took his Bachelor of Mathematical Science (1842) and that same year passed his examination for entrance to the École Normale, but as number 15 on a list of 22. Dis-

TUBERCULOSIS—DEATH RATE PER 100,000.

Year	Mass.	Eng. & Wales	Year	Mass.	Eng. & Wales	
1875	416.1	299.4	1900	251.9	190.1	
1876	380.4	286.5	1901	234.5	180.5	
1877	374.7	284.2	1902	221.0	173.7	
1878	365.6	292.3	1903	209.1	173.9	
1879	358.6	276.1	1904	219.8	178.1	
1880	378.9	270.8	1905	214.7	163.0	
1881	396.4	253.0	1906	212.9	164.5*	
1882	387.7	258.1	1907	178.6	160.6	
1883	385.6	259.1	1908	166.2	158.5	
1884	378.0	257.8	1909	160.7	152.4	
1885	377.1	243.0	1910	162.7	142.2	
1886	366.8	247.3	1911	154.4 crude	145.5	
1887	361.8	228.3	1912	148.1 crude	135.1	
1888	350.3	222.8	1913	145.0 crude	131.3	
1889	331.9	225.8	1914	143.1 crude	131.9	
1890	327.5	237.6	1915	141.6 crude	150.9	
1891	312.5	230.0	1916	149.2 crude	161.0	Civilian
1892	316.0	214.2	1917	145.9 crude	182.8	population
1893	306.6	214.2	1918	159.0 crude	195.0	only
1894	295.8	197.2	1919	128.0 crude	122.7	
1895	291.8	205.9	1920	113.8 crude	108.9	
1896	286.4	189.2	1921	98.5 crude	113.1	
1897	271.8	192.4	1922	93.8 crude	112.7	
1898	261.3	190.8	1923	88.5 crude	106.2	
1899	253.0	190.3	1924	------	105.8	

*To this point figures taken from "Tuberculosis in the United States," Census Bureau, 1907.

satisfied with this showing, he determined to go to Paris and prepare more thoroughly for the examinations which he again took the following year, standing fourth in a considerably larger class. In 1846 he received his degree at the École Normale in physical science and was retained as the assistant to Balard.

The École Normale is, perhaps, the most difficult of all French Schools both in the severity of its entrance examinations and those preliminary to the granting of a degree. Its faculty is chosen from the most expert of the nation's teachers. Here are gathered the young men who are ambitious to achieve fame in the teaching profession. Pasteur had made a brilliant record in his years as a student.

While acting as an assistant, Louis Pasteur continued his studies, working for his doctorate. His subject for investigation was the puzzling behavior of salts of tartaric acid. There were two of these acids known which apparently had the same chemical composition and yet their salts were unlike in their chemical and optical behavior. Those of tartaric acid turned the beam of polarized light to the right, but the salts of para-tartaric acid had no effect upon the polarized ray.

Pasteur examined the minute crystals of salts of these acids under his microscope and discovered, though not until after several months of work, that para-tartaric acid salts were made up of two sorts of crystals, a right-handed and a left-handed form which bore to each other the same relation as an object and its mirror image. The right-handed form came from what had heretofore been known as tartaric acid, the left-handed form had not before been discovered. It turned the ray of polarized light to the left and naturally, since para-tartaric acid salts were a mixture of the two, they neutralized each other and consequently there was no effect on the beam of polarized light.

When Pasteur, after weeks of unsuccessful work, finally made this discovery, he was so excited that he rushed from his little laboratory out into the hallway and encountering a fellow student, threw his arms around his neck and kissed him on both cheeks. The École Normale is not a co-educational institution.

When Pasteur reported his discovery, Biot, the professor under whom he was working, listened attentively then went and brought in a bottle of a salt of para-tartaric acid. He watched Pasteur make up the solution and produce the cystals by evaporation. He then instructed him to separate out under the microscope the two sorts of crystals. It was a laborious job, for

the crystals were very tiny, but finally two little heaps were piled up on the table. "Now," said Biot, "you claim that these crystals on the right will turn the ray of light toward the right while those on the left will turn them in the opposite direction?" "Yes," replied Pasteur, "that is my claim." With that Pasteur was dismissed. Biot, himself, wished to examine the solutions of the crystals under the polariscope, but Pasteur was instructed to return the next day. Meantime Biot had made the experiment and found that Pasteur was correct and when Pasteur returned the next day, Biot threw his arms about him and kissed him. Thus he expressed his gratitude for having a pupil who could make so brilliant a discovery.

At twenty-six years of age the young Pasteur, now with his doctorate, was sent by the Director of Education to the Lycée of Dijon as Professor of Physics. The next year he was moved at his own solicitation to the University of Strassburg as substitute professor of chemistry.

He was introduced at once into the family of the President of the Faculty and met his daughter, Marie Laurent, with whom he promptly fell in love. Within two weeks of his arrival in Strassburg, he had asked the young lady's father for her hand in marriage and had been accepted as a future son-in-law. As Pasteur moved on to greater and greater achievement, success was due in no small measure to the solicitude of his wife, who cared for him tenderly, aided him constantly with expert assistance and courageously upheld him in his days of discouragement. The fruition of his rate genius was made possible by her unfailing faith and devotion.

He remained at Strassburg until 1854, having been made full professor two years prior. He moved then to Lille as Professor of Chemistry and Dean of the Faculty. Lille was the center of a great sugar and alcohol industry. In response to an appeal from the manufacturers whose alcohol frequently turned out badly because the process of fermenting the sugar went wrong, Pasteur began an intensive study of fermentation. The microscope which had been his constant aid in unravelling the mysteries of the right-handed and left-handed crystals of tartaric acid, which work had given him early fame, was again brought into requisition. He found the micro-organisms in the fermenting sugars and proved that certain specific ones were responsible for the process as a result of their own vital activities. Furthermore, he found that other undesirable organisms caused the process to go

wrong. This was totally at variance with the prevailing opinion supported by such great men as Gay-Lussac and Liebig, who thought fermentation was the result of chemical disintegration—a resultant of death and decay, not of life. Thus was this man who studied to teach physics, who made his early fame in investigations in chemistry, launched in the study of biology, in which field he has made his lasting reputation.

In 1857 when 35 years old he was recalled to the École Normale as its administrative head. Here in a little garret room in an outbuilding he established his laboratory and worked assiduously at his scientific pursuits in addition to busy days occupied with administrative duties. Here he successfully demonstrated that the living organisms producing fermentation always come from previously existing ones of the same sort. It was the old question of spontaneous generation which Spallanzani thought he had settled. When, however, Priestley and Lavoisier showed that oxygen is necessary to life, it was necessary to demonstrate that boiling the nutrient solutions in the flasks did not drive out the essential air and so prevent the appearance of living things from the non-living.

These investigations, the successful issue of which can be stated in a few lines, were not accomplished over night. They were each the result of years of patient experimentation and study. But tenacity of purpose was a characteristic of Pasteur. Once started on a line of investigation, he hung on through months of toil until the matter was cleared up to his own satisfaction. It is a striking fact, too, that the motive for all his painstaking research was not merely a love of science for its own sake but invariably an overwhelming passion to help his fellow men.

In 1863 there came to him an appeal for help from the wine manufacturers of his old boyhood home at Arbois. The grape juice in the vats undergoing fermentation into wine often became "sick" and the wine turned out stringy or had a vile taste. So Pasteur established a laboratory in Arbois in an old cafe. With such home made apparatus as the local carpenter and tinner could construct, he began a study of wines. The faithful microscope was once more brought into play. The wine industry of France yielded an income of 500,000,000 francs, and the franc was to France what the dollar is to us. Again Pasteur found that certain tiny living things, only visible under the high powers of the microscope, were responsible for the proper change of grape juice to wine. When other sorts got into the juice, the process went

wrong and the wine became "sick" as the wine merchants put it. He knew from his studies on spontaneous generation that the organisms could only come from others of their own kind.

He found after trying many methods that all these organisms could be killed by heating the grape juice or the wine to a temperature of about 170° F and holding it there for some twenty minutes, a process we now call pasteurization. So he advised the wine manufacturers to so heat the grape juice. The vats and other utensils used were to be scalded out to kill all foreign organisms. Then they were to put into the vat of juice a few pailfuls of wine that was fermenting properly so as to sow the right organisms in it. When the wine was made, it was again to be pasteurized—though that term was not then used—and stored in bottles or kegs that had been carefully scalded so the wine would keep indefinitely and not spoil.

In 1865 came an appeal for help from the south of France. The silk industry was threatened with extinction. Some disease was killing the silk worms. It was Dumas, Pasteur's old teacher of chemistry, himself a native of southern France, who came to Pasteur and begged him to go and see if he could not discover the cause of this disease and some remedy for it. Pasteur objected that he knew nothing about silk worms or the diseases of silk worms, but he was finally persuaded to undertake the problem. It was a pitiful sight that he encountered when he went down to Alais. The silk industry had been yielding an income to France of 50,000,000 francs annually. But now the factories that wove the silk into cloth were closed because silk could not be obtained. The farms were desolate for the farmers had been making their living in rearing silk worms. A region once exceedingly prosperous was on the verge of starvation.

On his way down to Alais Pasteur stopped to see Fabre, the great French naturalist. He told Fabre why he had come to this region and asked to be shown some silk worms. Fabre brought out a tray of mulberry leaves on which silk worms were feeding. "But," said Pasteur, "I don't see any silk." Then Fabre brought him some of the cocoons. Pasteur picked one up and found there was something inside that rattled. He asked what made the rattle. Then Fabre told him that when the worms were fully grown, they spun around themselves for protection a cocoon made of a single thread of silk wound round and round. Then Pasteur asked where the worms came from and he was shown some of the moths that hatched

from the cocoons and told how these moths after mating laid the eggs which in due course of time developed into the worms, or better called, the larvae. So Pasteur took his first lesson on the life history of the silk worm.

It was already known that the silk worms suffering from this disease had, in their tissues, little transparent globules of living material that could be seen only under the microscope. The diseased worms ceased eating, the bodies grew flabby and finally as the worms died there appeared many little black specks like particles of pepper on the outside of the bodies. It was this peppery appearance that gave to the disease its name of pebrine.

Pasteur examined the sick worms and readily found in their body fluids these little living globules. He found them also in the bodies of the moths and even in the eggs which the moths laid. It was evident that their presence was a sure sign of the disease and so he concluded that if the farmers would examine under the microscope the fat bodies from the moths after they had mated and after the female had laid her eggs, they could tell whether that pair of moths was diseased or not and whether the eggs should be saved or destroyed. At first the farmers threw up their hands in disgust. How could they, mere farmers, use a microscope, the tool of a scientist? But Pasteur taught a number of children how to make this determination and then the farmers thought that if their children could do it, they also could learn how.

But when the farmers followed Pasteur's instruction, they found that still a large percentage of the worms died. They were so angry at Pasteur they talked of driving him out of the country. Now Pasteur soon discovered the cause of this failure. Because he had always found the transparent globules in the fat bodies, he thought that if the moth was sick with the early stages of the disease, their fat bodies would always show it. But he found that the tell-tale bodies might be absent from the fat masses but present in other parts of the moth. He had been so anxious to find a way to help the farmers that he jumped to a conclusion on the basis of too few observations. It was now very difficult for him to persuade the farmers to give the moths a more thorough examination. But he, himself, and his assistants were raising perfectly healthy silk worms from the eggs laid by moths in whose body fluids and body tissues none of the transparent globules could be found, so that a few of the

farmers to whom he showed this healthy stock were persuaded to take some of it and start their cultures of the silk worm all over again, following Pasteur's method to make sure that the moths remained healthy.

Meanwhile Pasteur was experimenting. He found that if the juices of crushed sick worms were sprinkled on mulberry leaves and these leaves fed to healthy worms, these healthy worms caught the disease. Thus Pasteur and his assistants had discovered the cause of the silk worm trouble and a method of avoiding it. A second disease of the silk worms was also studied and successfully combatted.

The history of the five-year battle has been condensed into a few paragraphs. Early in his work at Alais, Pasteur received word of the dangerous illness of his father. He hastened to the boyhood home at Arbois only to find that his father was dead. Later his wife and daughter were coming down to Alais to be with him there when the daughter contracted typhoid fever. She was taken back to Paris so she could have the best of medical attention and Pasteur watched at her bedside, a faithful nurse, through weary weeks of illness. In spite of his care the daughter died. Still Pasteur went back to his task at Alais. Then he himself was stricken with paralysis and taken back to Paris with little hopes of recovery. But he told his doctor that he could not die, that here was an important industry of his beloved country that was threatened and he felt that in time he could save it. He must, therefore, get better to go back and finish the job he had started. And he did not die. He was always afterwards, however, a cripple, one leg partially paralyzed and his hands so drawn out of shape that later experiments had largely to be done by his assistants, he merely giving the directions. As soon as he was able to travel, he went back to Alais to the task, his indomitable perseverance again asserting itself.

In 1867 when Pasteur was 55 years of age, he was relieved of the administration of the École Normale and made professor of chemistry at the Sarbonne. While he was recovering from his stroke of paralysis, his new laboratory in the garden of the École Normale was being rushed to completion at the order of Napoleon. The Franco-Prussian war, which came on in 1870, interrupted the course of his research work. In the days of reconstruction that followed, Pasteur undertook the study of beer manufacture, for in the process of fermentation the

materials sometimes went wrong and the beer was spoiled. It was Pasteur's ambition to have France produce a beer that was superior to the German product. He felt this job a patriotic duty, one way in which he could recompense his country for the losses suffered in the war. Again he was able to discover under his microscope the organisms responsible for the fermentation and also the presence of other tiny living things which interfered with the normal fermentation and ruined the beers.

In 1873 he resigned his chair of chemistry at the Sarbonne and the following year the National Assembly voted him an annual grant of 12,000 francs so that he could devote himself to research. He undertook the study of chicken cholera in the hopes that he could discover some preventive for the disease so that the farmers' flocks would not be constantly decimated, the farmers thereby suffering great financial loss. He discovered the bacterium that was responsible for the disease and found out how to grow it in broth made from the tissues of the chicken. Months of experimentation followed, but he was unable to discover any means of prevention. At last, however, a fortunate accident gave him a clue to the solution of the problem. When called away from his laboratory, he left some of the cultures in unstoppered tubes on his laboratory desk. These dried out in his absence. On his return instead of throwing them away as a less inquisitive person would have done, he tried injecting them into some chickens. Apparently, however, they had lost their virility and produced only a mild form of the disease. A few days later when fresh cultures had been obtained he asked his laboratory assistant for some chickens into which these fresh bacteria were to be injected in continuance of his experiments. Now it so happened that the assistant brought him the same chickens into which the partially dried out cultures had been injected. Pasteur was surprised to find that the chickens did not come down with the disease as former chickens had always done when treated with fresh cultures. Thinking over this puzzling situation, he saw a possible solution of his difficulty. Might it be that the bacteria, weakened by the drying process, had developed in the chickens a resistance to the more virulent forms. He repeated the experiments more carefully, drying out some of the cultures for a couple of weeks, others for ten days, still others for eight days, etc. Then he injected the fourteen-day cultures into some chickens, a few days later the ten-day-old cultures, then the eight-day,

and so on until finally he could inject the fresh germs without producing the disease. So he found that chickens could be treated with less virulent germs and so gain immunity from an attack of chicken cholera. He simplified the procedure by repeated experiments until farmers were able to give the needed treatment and so protect their flocks.

Meanwhile, over in Germany Robert Koch had been making a study of a disease of cattle known as anthrax or splenic fever. He had demonstrated that this disease was due to a micro-organism in the blood of sheep and cattle and this he had done before Pasteur's experiments on chickens. Furthermore, Koch had discovered a method of weakening the bacillus of anthrax so that it was possible to protect sheep and cattle by injections from catching this disease. In France, as well as in Germany, the disease was much dreaded by farmers, for often when it made its appearance in a flock of sheep or herd of cattle they all died off with great rapidity. Pasteur had also been studying this disease. He profited by Koch's work and was anxious to put this means of protection into the hands of the farmers. He therefore gave a dramatic demonstration of the effectiveness of the protective injection. He arranged with the farmers in the neighborhood of the little town of Melun not far from Paris to provide him with a flock of fifty sheep and also some cattle. These were divided into two lots, equal numbers in each. Pasteur and his assistants were to give the preliminary protective injections to one lot only. Then they were to inject both lots with the virulent germs and Pasteur predicted that all the unprotected would promptly come down with the disease and die and that none of the protected animals would suffer. It was a bold move, but Pasteur was confident of the results.

Some of his opponents, however, were suspicious of his method of procedure and said that he would use only the top portion of the virulent culture on the protected animals while he would inject the bottom portion of the culture, which alone contained the virulent germs, into the unprotected animals. Pasteur, however, learned of this before the day of the final test and insisted that his opponents should shake up the culture thoroughly to satisfy them that it was uniform in its character throughout.

On the final day of the test after half of the animals had been injected several times with the protective cultures of increasing strength, Pasteur and his assistants gave all the animals the

injections of virulent germs. This was done in the presence of a crowd of farmers, veterinary surgeons and noted scientists. One can imagine with what intense interest and undoubtedly with some forebodings Pasteur awaited the results. As the days went by the protected animals remained perfectly well with one exception that showed a slight fever. Within a few days, however, the unprotected animals began to sicken with the disease and all died. Pasteur was never merely a scientist. His investigations were always undertaken with a view to helping his fellow men.

In 1883 to show appreciation of his work the French Chamber voted to increase his annual grant to 25,000 francs. Meanwhile Pasteur had become convinced that disease was always due to the presence of micro-organisms. This idea had been growing in his mind for a long while. He had found that when the process of fermentation went wrong in the wines and they became "sick," as the wine merchants said, it was due to the presence of these tiny living things. It had been proved that the diseases of the silk worms were caused by the presence of such living organisms. He had found that the difficulties in beer manufacture were similarly caused. Koch had proved, and his was the first careful proof, that anthrax in cattle was a germ disease. Pasteur's work on chicken cholera had convinced him that it also was a germ disease. Moreover the investigations began to show the possibility of preventing these diseases. And so Pasteur determined to study a human disease and see if he could not find a means of preventing it.

Pasteur was now getting on in years. He was crippled from his attack of paralysis. His experimental work must be done under his direction by his assistants and much credit is due them for his successes. A less determined man would have felt that he was entitled to rest and to spend his remaining years, full of honors, in comfortable enjoyment of his ample pension. Not so Pasteur. He threw himself into the new investigations on hydrophobia with the enthusiasm of a young man.

Pasteur reasoned that since the person or animal suffering from this malady died in convulsions the seat of the disease must be in the nervous system. So he searched with particular care the brain and spinal cord of dogs dead with the trouble with his microscope to find if possible the germs he felt must be present. But with no success. He concluded they must be too small to be seen even with the aid of powerful lenses. He found

he could give hydrophobia to a well dog by putting some of the brain or spinal cord of a dog dead of hydrophobia into these organs in the healthy animal. So he felt he had been correct in his location of the parts affected. But he could make no cultures with which to experiment.

Then he recalled his experiments in the prevention of chicken cholera. Would drying the spinal cord from a dog that had died of the disease reduce the virulence so that such dried material kept in glycerine could be used as a preventive? The experiment was worth trying. Some bits of the spinal cord were dried out for two weeks, others for thirteen days, others for twelve and so on. Then the material ground up in glycerine was injected into the spinal cord of a dog, the fourteen-day-old stuff first, then the thirteen-day-old and the injections continued day after day until the dog was getting fresh spinal cord from an animal that had just died of the disease. It takes about thirty days for a well dog bitten by a mad one to show symptoms of the disease. Imagine with what anxiety Pasteur and his assistants waited. At the end of thirty days the dog used as a subject was perfectly well, playful as any puppy and it never did manifest any signs of the disease. The experiment was repeated many times successfully.

Pasteur was for giving the preventive treatment to all dogs in France. But that was a huge task. It occurred to him that the preventive might also serve as a cure. So when a dog was brought to his laboratory that had just been bitten by a mad animal, he began giving it the series of injections. Would it in thirty days become mad or would the injections save it from death? It was a time of suspense. Day after day the injections of increasing strength were given and at the end of the thirty days the dog showed no signs of hydrophobia —nor did it afterwards. The injections would cure as well as prevent the disease if given promptly. Again the experiment was often successfully repeated. Even animals that did not get the treatment until several days after they were bitten did not come down with the malady.

Then one day—a memorable one—the 6th of July, 1885, there was brought to his laboratory a nine year old boy, Joseph Meister, who had been repeatedly bitten by a mad dog. His mother implored Pasteur to give him the injections. Pasteur hesitated. No one knew that the treatment, safe on dogs, would be safe for human beings. But he did know that the

boy was almost certain to die of the disease if the injections could not save him. So Pasteur consented to try them. Can you picture to yourself the suspense of those thirty days? The lad was cheerful through it all, perfectly confident that the great savant would save him. And his confidence was justified. He had no symptoms of the dreaded malady. In October of the same year came a shepherd lad, Jupille by name, who had been badly bitten by a mad wolf in a successful effort to keep it from attacking some younger lads. Again the treatment was successful. Patients began to pour in. Within a little over a year more than 2600 were treated and only 31 died of the disease.

From all over the world money began to pour in to build for Pasteur an Institute for the treatment of hydrophobia and for research to prevent other human diseases. The Pasteur Institute as it was named still stands on the Rue Dutot in Paris. In the garden about it there is a bronze statue of Jupille, protecting his younger friend from the mad wolf. Jupille became one of Pasteur's great admirers and an able assistant in the Institute.

Honors had been coming thick and fast to Pasteur. He had been granted the medal of the Legion of Honor, made a member of the French Academy of Science, The Academy of Medicine, and of the Academie Francais, a chair in which is the greatest honor within the gift of France. Foreign nations and scientific societies had given him medals, memberships and citations of appreciation.

Pasteur's seventieth birthday was celebrated by a great gathering of scientists and representative men from the nations of the world at the Sarbonne in Paris to pay homage to his greatness. Pasteur was greatly moved by the tributes of respect paid to him in the great auditorium of the university where he had been a student and a professor. His reply, expressive of his appreciation, was simple and sincere. Then lifting his face to the gallery where sat rows of students from the university, from his beloved École Normale and from preparatory schools, his own Lycée Saint Louis included, he said, "Live in the serene peace of laboratories and libraries. Say to yourselves at first: What have I done towards my own education? And then, in proportion as you advance: What have I done for my country? Do so up to the moment when, perhaps, you may have the immense happiness of thinking that you have contributed in some measure to the progress and well-being of humanity.

But, whether life favours your efforts to a greater or a less extent, one must have earned the right to say when the great goal draws near: 'I have done what I could.' "

Three years later he lay dying, surrounded by devoted friends and the even more devoted scientists, his assistants for many years. With his hand clasped in that of his devoted wife, he gave his body back to that Nature he had so loved, his spirit to the God he had so devoutly served. His was a great life. He was buried under the dome of the Pasteur Institute—a fitting monument to such a man.

I trust that in your absorption in the stirring career of this noted scientist you have not lost sight of the purpose in its presentation. Here is the sort of matter that can be used, that must be used, to give students new emotionalized standards, renewed ideals of the greatness of service to their fellows. We have neglected too long such objectives in our science teaching. The inspiration of such devotion is one of the great heritages of science to human life. It should be made an important part of the contribution that science instruction gives to the individual student.

Central Association of Science and Mathematics Teachers

The Monthly Message

The Annual Meeting of the Central Association will be held at the University of Chicago, November 30 and December 1, 1928. Provision has been made for every detail that may help in caring for a large attendance. The program should be the main attraction and is given on pages 900 and 902 of this issue of SCHOOL SCIENCE AND MATHEMATICS.

Exhibits. Numerous large and well-planned exhibits will be a special attraction. Educational business houses have taken more than ordinary interest in the affairs of this Association. You will be pleased with their display, attention and service.

The Annual Dinner will be held in Ida Noyes Hall on Friday evening at 6:45 o'clock. Tickets will be $1.00 and must be reserved in advance. Send your reservations to Mr. O. D. Frank, The School of Education, The University of Chicago. Your card should reach him by Wednesday, November 28. John Mills, Member of the Technical Staff, Bell Telephone Laboratories, will give the after dinner address, subject: "Electrical Eyes and Their Use in Communication." This address will be illustrated in a fascinating manner and will be given in the Theatre of Ida Noyes Hall at 8:00 o'clock. Admission by card. Do not miss this dinner and address.

W. F. ROECKER, President.

THE DEVELOPMENT OF THE GRAPH FOR EXPRESSING FUNCTIONALITY.

By G. A. MILLER,
University of Illinois, Urbana, Ill.

It is well known that square units of area and cubical units of volume were used by the ancient Egyptians and by the ancient Babylonians, but it is not certain that they knew that a quadrilateral whose four sides are equal separately to one linear unit has a maximal area when it is a square and that a parallelopiped whose edges are separately equal to one unit has a maximal volume when it is a cube. Just as we find the number of square units in a rectangle by means of the product of two adjacent sides so we can find the number of unit parallelograms in a general parallelogram with the same angles by means of the product of two adjacent sides, and the graphical solutions in the two cases are exactly the same. Similar remarks obviously apply to the finding of the number of units in a rectangular parallelopiped and in a general parallelopiped respectively. It seems probable from the work of Ahmes that the ancient Egyptians found the area of a triangle graphically, and in a graphical solution the square unit does not always seem to be the most natural.

While it seems reasonable to assume that the square unit and the cubical unit were the earliest units of area and volume respectively which were commonly used in view of their symmetrical properties, and while this furnishes another instance of the great influence of symmetry in the early development of mathematics, it is unreasonable to assume that when these units were first used the human race was far enough advanced intellectually to realize the functional relation existing between them and the units obtained from them by slightly changing the angles involved therein. In particular, it seems unreasonable to assume that the ancients at first realized that a parallelogram with unit sides has a smaller area than a square with the same sides when the angles of the former are almost equal to a right angle. This unreasonableness becomes more clear if we recall the fact that the sine of an angle changes relatively slowly with the angle in the immediate neighborhood of a right angle.

Mathematical historians seem to have paid too little attention to the incentives for mathematical study which are involved in the choice of units of measurement, especially since such units had to be selected very early in view of their practical usefulness.

These units do not only naturally raise the question of maxima and minima but they also involve the fundamental concepts of function and of graph of a function, since the area of a parallelogram with unit sides varies as the sine of the angles involved therein. It is, of course, not assumed that the ancients at first meditated on such functional relations or on the groups of the movements of the square and the cubical units which they adopted, but it is important to note that these fundamental concepts are involved in what was so frequently before their eyes and may have exercised an unconscious influence. It is also desirable to observe that while there seems to be no definite evidence which supports the assumption that parallelograms with unit sides and angles which are nearly equal to a right angle were ever used as units of area, and that the corresponding parallelopipeds were ever used as units of volume, the possibility of the use of such units is suggested by rules of finding areas which appear in the work of Ahmes, and also by the rule of finding the volume of a truncated pyramid which appears in noted Moscow Mathematical Papyrus, and the use of such units seems to furnish the simplest explanation of these rules.

One of the most important facts in the history of mathematics is the selection of units of area and of volume whose edges are linear units. It is due to this fact that numerical relations can be established between magnitudes of different dimensions, and hence that numbers play such a dominating rôle in the development of mathematics. It should, however, not be assumed that such units were the only ones which were extensively used by the ancients. We find even in the work of Ahmes units of land-measuring which were not squares. What we desire to emphasize is the fact that square and cubical units were commonly used and that their selection naturally raises fundamental mathematical problems which were not completely solved for many centuries but which probably influenced the trend of later mathematical thought profoundly.

While a scale is commonly associated with a graph and hence the consideration of units of measure is intimately related to its construction, it is not customary to regard the unit of measure as the most important feature of a graph. It is well known that the ancient Greeks developed a kind of geometric algebra by means of which they were able, in particular, to find a root of a quadratic equation whenever such an equation has a positive root. There is, however, a difference of opinion among mathe-

matical historians in regard to the question whether these solutions should be regarded as graphical solutions of the quadratic equation since they relate to geometrical questions and not directly to the interpretation of the solution of an algebraic equation. Somewhat later the Arabians came closer to what is now regarded as a graphical solution of equations, but they confined their attention to the consideration of positive numbers and hence they could not realize the wide range of usefulness which is now commonly associated with a graph and a graphical solution.

During the Middle Ages the scholastic school developed a singular method by means of which function theoretic considerations were related with graphic representations. This method was taught extensively in the early universities, especially by means of the *Tractatus de latitudinibus formorum* by Nicole Oresme (about 1323-1382). This work was a kind of ordinate geometry, using only positive ordinates to represent varying intensities in certain intervals of time. It exhibited functional relations accurately by means of straight lines in the case when the acceleration is constant, just as is commonly done in a modern graph for this particular case. Other functional relations were exhibited less successfully by means of straight lines and arcs of circles, and the method, in general, can be regarded only as an approach to the modern graph notwithstanding the fact that it represents an important step towards such a graph.

According to Tropfke's *Geschichte der Elementar-Mathematik*, volume 6, page 96, the earliest graphical representation of physical phenomena in the modern sense appeared in 1684 and was due to R. Plot. This was a natural outgrowth of the somewhat earlier work by R. Descartes and P. de Fermat relating to the solution of algebraic problems by geometric method, which led to the important branch of mathematics known as analytic geometry. A fundamental feature of this subject is a fixed system of coordinates. In the plane, traces of special systems of coordinates appear already in the works of the ancient Greeks, especially in the works of Apollonius, but the general use of such a system in the modern sense of the word did not appear until a considerable time after the days of Descartes. The use of such a system was greatly retarded by the difficulties presented by the operation with negative numbers. These difficulties were not fully mastered before about the beginning of the nineteenth century.

As regards the practical usefulness of graphical methods it may be of interest to quote here a paragraph from the preface of the recent important work entitled *The Calculus of Observations* by E. T. Whittaker and G. Robinson, 1924, as follows: "One feature which perhaps calls for a word of explanation is the prominence given to arithmetical, as distinguished from graphical methods. When the Edinburgh Laboratory was established in 1913, a trial was made, as far as possible, of every method which had been proposed for the solution of the problems under consideration, and many of these methods were graphical. During the ten years which have elapsed since then, the graphical methods have almost all been abandoned, as their inferiority has become evident, and at the present time the work of the Laboratory is almost exclusively arithmetical. A rough sketch on squared paper is often useful, but (except in Descriptive Geometry) graphical work performed carefully with instruments on a drawing-board is generally less rapid and less accurate than the arithmetical solution of the same problem."

The prominence of the graph in our modern elementary algebras cannot be justified from the standpoint that in mathematics we should use a method only after we can prove its validity. When a student finds the location of various points representing the values of a function at these points and then draws a curve through these points and calls it the graph of the function in a certain interval he is obviously not proceeding in a mathematical manner and he may be cultivating very pernicious habits of thinking. In doing this he is making use of common induction instead of mathematical induction. It is singular that in elementary geometry we emphasize mathematical rigor and frequently prove what appears perfectly obvious to the student, and then in elementary algebra we sometimes draw conclusions which are based on considerations lying far beyond the attainments of the student. The rigorous study of many of the graphs with which the student of elementary algebra is often confronted cannot be undertaken without the use of the calculus and results developed in analytic geometry.

On the other hand, it is desirable to cultivate the mathematical imagination. The imagined functionality which many graphs present for the student of elementary algebra may tend to arouse his interest and to cultivate an appetite for an intellectual penetration of the mysteries which they have in store. Moreover, these curves furnish interesting pictures which tend to

break the monotony of the abstract symbolic language representing the ordinary algebraic developments. They frequently serve to predict functionality before the student is prepared to grasp this functionality from the related algebraic expressions. The arithmetization of the functionality thus suggested is in line with the great fundamental tendency towards arithmetization, which has dominated the development of mathematics since the times of the ancient Greeks, and also largely dominates the development of mathematical insight on the part of the individual student.

The study of the development of the graph for expressing functionality depends largely on the definitions of the terms graph and functionality. It is well known that one of the earliest definitions of circle is equivalent to the statement that it is the locus of all points which are at a certain fixed distance from a given point called the center. Hence the circle is the graph which expresses this functional relation between all its points and a certain other point. In polar coordinates it is the graph of the equation $r=c$. It is however, not probable that this functional relation was an important incentive for the early study of the circle. This and other curves seem to have been studied by the ancient Greeks on account of their interesting geometric properties and not primarily because they represented functionality. The fact that they exhibit functionality may, however, have been more clearly seen than the records which are extant disclose. This is especially true in regard to the functionality expressed by the more general conic sections as developed by Apollonius and others.

In view of the fact that the trigonometric functions occupy such a central position in the development of the function concept it is interesting to note here that the well known graphs of these functions which now appear in many of the textbooks on elementary trigonometry began to be published during the seventeenth century. Roberval (1602-1675) published a graph of the sine curve in the first two quadrants and somewhat later Wallis gave a graph of the same curve through two cycles. About the same time various other writers began to consider the graph of this and of the other trigonometric functions. The tangent and the secant curves for two cycles appeared for the first time in a posthumous work by Cotes (1682-1716). Hence it results that the development of the graph for expressing functionality was well advanced by about the beginning of

the eighteenth century even if the theory of negative numbers was then still in a very unsatisfactory state. In fact, the great usefulness of negative numbers for the graphic representation of functions contributed strongly towards the adoption of these numbers on the part of many writers even before their legitimacy had been fully established.

LIGHT CHANGE GIVES NEW ATOMIC VIEW.

A very recent discovery by a Hindu scientist, Professor C. V. Raman, that intense light of a single color is partly changed to other colors when it shines on various transparent substances "opens up a wholly new field in the study of molecular structure." This statement was made recently by Prof. R. W. Wood, of the Johns Hopkins University, in announcing that he had completely verified Professor Raman's discovery in the private laboratory of Alfred L. Loomis, at Tuxedo Park, N. Y.

According to Prof. Wood, who has just completed an investigation of the subject with improved apparatus and a more powerful spectroscope than the one employed by Raman, the effect occurs when monochromatic light, which is light of a single color, and, unlike white light, is entirely of a single wave length, shines on transparent substances such as quartz, chloroform or water. The light that is scattered from the material is mostly of the same color, or wave length, as that of the light illuminating it. The spectroscope, the instrument that analyzes light, shows, however, that part of the light is changed to wave length a little longer or a little shorter than the source. On the spectrum photographs the result is a heavy line attended on either side by narrower and fainter lines. The fainter groups of lines on one side are the same as those on the other, except that they are reversed, as if reflected in a mirror, the center line being the mirror. Professor Raman found only a single and very faint line on the high frequency side of the exciting line, but Professor Wood has found groups of lines on this side almost as strong as the groups on the other in the case of carbon tetrachloride and chloroform.

The importance of the discovery comes from the fact that the difference between the frequencies of the light given off, and those of the light which shines on the substance is precisely the same as the frequencies of the absorption bands of the same substance for infra-red light—light which is vibrating too slowly to be seen or even to be recorded on the photographic plate without great difficulty. By means of the Raman effect, the physicist can now study these bands of absorbtion indirectly.

Prof. Wood also pointed out that the effect was one of the most convincing proofs of the quantum theory of light, which supposes that light consists of separate pulses, or "quanta" rather than waves, as was formerly supposed. Only by the quantum theory, he thinks, can the effect be explained.

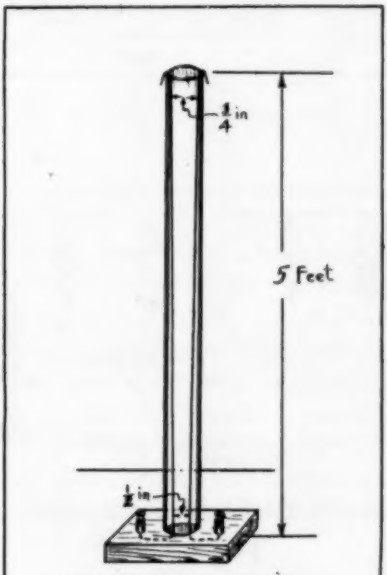
Most of his research was done with crystalline quartz, or such liquids as chloroform and carbon tetrachloride, illuminated with a mercury vapor arc lamp. He is now planning to repeat the work with a spectroscope of 40 feet focus, which will give even more convincing results than those he has now obtained.—*Science News-Letter.*

DEMONSTRATIONS IN ELECTRICITY.

By R. C. Colwell and M. C. Holmes,
West Virginia University, Morgantown, W. Va.

The earliest known electrical experiment and the first one shown to a beginning class in electricity is to electrify a stick of rubber (or amber) by friction and attract small pieces of paper to it. A more striking experiment of exactly the same nature is to blow up an ordinary balloon with gas until it falls very slowly under gravity. The balloon, when electrified by rubbing with a catskin, will stick to the operator's arm or back and can be thus transported about the room. If the electrified balloon is held above the head and away from the body of the operator it will fall toward him when allowed to drop. These simple experiments show the attraction between the electricity on the balloon and the induced electricity on the body of the demonstrator.

Two wires or rods about ten feet in length (four or five feet will do) are supported in a glass tube of the same length in such a way that the lower ends are one-half an inch apart, while the upper ends are three-quarters of an inch distant from one an-

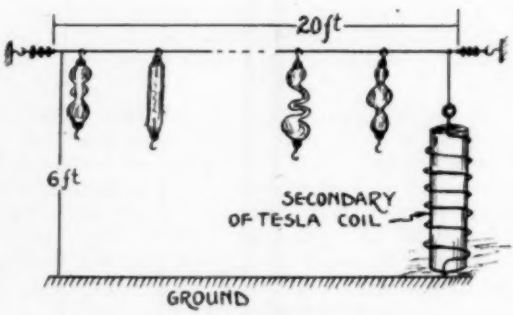


THE CLIMBING SPARK

Fig. 1.

other. The two wires from an induction coil are connected to the lower ends of the rods. Initially all the air in the tube is homogeneous, so that the first spark chooses the shortest electrical path which is also the shortest geometrical path—that is, the first spark passes at the bottom. The passage of this spark creates a group of ions and heats the air as it passes. This hot air and the ions rise slowly so that the next spark passing most easily through the path containing the ions will be a short distance above the first spark. The third spark appears still higher. Hence the spark appears to climb the wires until it reaches the top of the tube. The ions then pass out at the top and the next spark begins at the bottom again. If the tube is closed at the top, with a tight fitting cork, the ions and therefore the spark will travel upward very slowly and remain at the top. A blast of compressed air down the tube from the top will make the spark travel down the tube; by applying the blast intermittently the spark can be made to oscillate up and down the wires.

When a great many instruments, such as vacuum tubes and Geissler tubes, are to be connected to an induction coil in the course of a single lecture, it is convenient to stretch two parallel wires the whole length of the lecture table and have a running

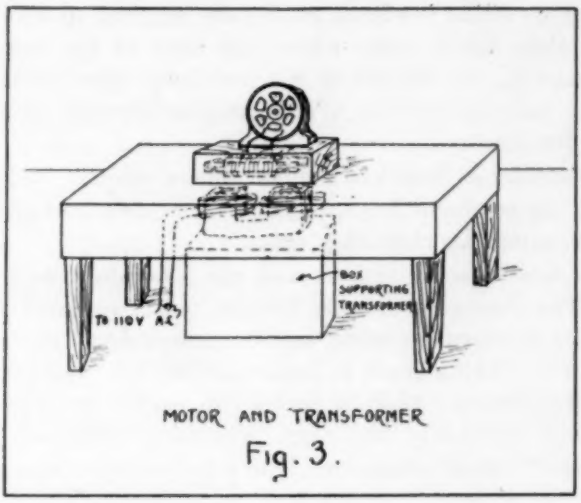


VACUUM TUBES ON SINGLE WIRE

Fig. 2.

connection on each wire. This obviates the necessity for moving the apparatus on the lecture table. A string of vacuum tubes connected to one of these wires (Figure 2) will light up brilliantly all the way across the lecture desk if one end of a Tesla Coil is connected to the wire. The potential drop through the tube is of course from the wire to the ground.

. The next experiment is to impress upon the students the fact that a magnetic field from an alternating current extends out in space and transfers energy over a fairly large distance. It also should make them wary of fuelless motors and other devices which operate apparently without any supply of energy.



MOTOR AND TRANSFORMER

Fig. 3.

The primary of an alternating current transformer is carefully concealed beneath a table; the secondary is wound and concealed in the base of a small portable motor (Figure 3). The motor is shown to the class without any outside connection whatsoever. When placed in proper position on the table it will whirr rapidly—stopping when it is moved away. A small lamp may be lighted at the same place on the table if its base contains a suitably wound coil. This experiment is shown after transformers have been discussed and the students are allowed to solve the mystery themselves.

There are more than 100 organs or parts of organs in the human body that have little or no function to perform, and that are useless relics of a time when they were important.

A STUDY OF DIFFICULITIES IN CHEMISTRY.

By Arthur R. Stewart,
Penn High School, Greenville, Pa.

This study was made in Penn High School at Greenville, Pennsylvania, during the year 1926-1927. The chemistry class was divided into two sections. Each section contained forty pupils at the beginning of the year. At the close of the year Section 1 contained thirty-four members, and Section 2 thirty-eight members. Eight pupils did not complete the course for various reasons.

Academic and commercial courses are given in the High School. All members of the academic course are required to take chemistry in their senior year, while only boys of the commercial course take it. At the end of the year there were twenty-three academic boys, twenty-seven girls, and twenty-two commercial boys in the class.

The commercial boys had studied general science, biology and physics; the academic boys, physics. The girls had no science before entering the chemistry class.

There were five recitations and one laboratory period each week. The class periods were flexible, thirty minutes, more or less, being given to recitation and the remainder of the fifty-five minute period being given to supervised study. The laboratory session lasted from 2:45 P. M. to 4 P. M., and longer if necessary, which was frequently the case. Brownlee, Hancock, Fuller, Sohon, and Whitsit's text, and Dull's Laboratory Manual were used.

The following are the results of the Terman Test, Form A, taken May, 1926.

Range in I. Q.'s	129-88
Median I. Q.	109
No. pupils below 97	10
No. pupils above 120	4

The classes were sectioned according to their I. Q.'s. There were some conflicts in the schedule that caused a few of the poorer students to be placed in the section with the higher I. Q.'s.

The purpose of the study was: (1) to make a study of the difficulties of the students in chemistry; (2) to make an analysis of the errors; and (3) to suggest methods of overcoming the difficulties.

The method of procedure in this study was (1) by questionnaires to the students, and (2) by securing data from tests throughout the year. Questions No. 1 and 3 were asked at the end of the first semester and again at the end of the year. No. 2 was asked at the end of the year. The tests were given approximately every three weeks. They were largely of the objective type, i. e., true-false, completion, and multiple choice. The tests were mimeographed and so arranged that all work, including calculations, could be done on one sheet of paper.

Question No. 1. What have been the most difficult parts of chemistry? The responses at the end of the first semester are in column No. 1, and the responses at the end of the year in column No. 2.

	No. 1	No. 2
Equations	33	26
Valence	24	8
Problems	14	18
Formulas	14	8
Dissociation	5	0
Atomic theory	3	2
Solutions	2	0
Organic chapter	0	7
Colloids	0	5
Theoretical parts	0	3
Properties of elements	1	2
Separation of elements from compounds	0	3

Electrolysis, hydrolysis, monthly tests, radioactivity, structural formulas, writing experiments and finding "unknowns" received one response each.

Question No. 2. How could the difficult parts have been overcome, or were they naturally difficult? The following are the replies.

More study	29
Naturally difficult	28
No part too difficult	4
By repeating "over and over"	4
By regular attendance	3
Disliked mathematical parts	3

By having more equations, by mastering valence, by learning tables in back of text, by more explanation at the beginning, and by application in short lessons each received one vote.

Question No. 3. What have been the most interesting parts of chemistry this semester?

	1st Semester	2nd Semester
Laboratory work	38	46
Study of elements	9	8
Study of sulphur	9	0
Demonstrations	5	3
Writing equations	4	1
Study of oxygen	3	0
Study of sodium and potassium	2	0
Properties of elements	2	2
Finding "unknown"		3
Outside reports by pupils		3
Study of iron		3

The following received one vote each: Study of hydrogen, air, chlorine, gases, photography, precious metals, mordants and dyes, metallurgy, metals, radium, organic chapter, and making tests for elements.

The study of difficulties will be given as found in the results of the tests. Problems caused the most trouble. The following list of problems is typical of what is found in most of our text books. The per cent denotes the part of the class that made errors in each problem.

PROBLEMS.

1. How much carbon is there in 21 lbs. of sodium bi-carbonate?.....91.2
2. If 150 c.c. of a gas at standard conditions weighs .40 g., what is the weight of a liter? What is its molecular weight?.....85
3. A certain substance contains 80% carbon, and 20% hydrogen. Its molecular weight is 30. What is its formula?.....78
4. Find the number of grams of potassium in 245 g. of potassium chlorate.....76.9
5. Find the per cent of water of crystallization in $BaCl_2.2H_2O$. Atomic wt. Ba 137, Cl 35.5.....75
6. How many liters of hydrogen will be produced by using up 5 g. of zinc with H_2SO_4? Atomic wt. S = 32, Zn = 65.....72.9
7. A quantity of hydrogen measures 190 c.c. at 17 C, and 580mm. Find the volume at standard condition?.....61.8
8. How many grams of sodium chloride are needed to yield with sulphuric acid 20 g. of HCl?.....57.1
9. How much water will be found in No. 11?.....53.9
10. Reduce 200 c.c. of gas at 27 C. and 600 mm. to standard conditions.....51.3
11. Twelve grams of oxygen will unite with how much hydrogen?.....48.7
12. Reduce to standard conditions 800 c.c. of gas at −30 C. and 780 mm. pressure.....40.2
13. Given 300 c.c. of gas at 3 C, and 750 mm. Find volume at 27 C. and 800 mm.....38.8
14. Phosphorus was allowed to stand in a tube containing 180 c.c. of air. After 24 hours the volume had decreased to 142 c.c. What was the percent of oxygen in the air?.....38.2
15. Given 420 c.c. of gas at 25 C. and 790 mm. Find volume at 5 C. and 730 mm.....33.7
16. 50 cc. of hydrogen will require how much oxygen in burning?.....32.8
17. If the atomic number of Mg is 12, show by a diagram the arrangement of the electrons about the nucleus and give the valence.....30.4
18. Reduce to standard conditions 1500 c.c. of a gas at −20 C. and 700 mm. pressure.....28.5
19. If 2.18 g. of sodium chlorate lost .96 g. of oxygen in heating, what per cent was oxygen?.....26.
20. Given 150 cc. of gas at O C. and 380 mm. What will be the volume at 273 C. and 760 mm?.....20.8

An analysis of the difficulties of the above problems is given next. The direct and inverse variations in the gas volume problems cause a lot of errors. Some will forget to change the Centigrade reading to Absolute, while a few will even forget the number 273. Others will forget that standard conditions are OC. and 760 mm. In addition to these difficulties a few will almost invariably make some mistake in multiplication or with the decimal point.

The volumetric ratio 2:1, and the gravimetric ratio 1:8, confused some in problems 9, 11, and 16. The very idea of simple proportion frightens a few pupils. No. 10 was given about three weeks after Nos. 12, 13, 15, 18 and 20. Most of the difficulty was caused by forgetting the standard conditions.

Various difficulties arose in No. 3. Some forgot the atomic weight of carbon, others computed with atoms instead of atomic weights, getting C_4H and neglecting the molecular weight of 30. In No. 5 some forgot to take 2Cl or $2H_2O$; others did not add the $2H_2O$ to the $BaCl_2$; A few forgot which way to divide, a matter of percentage. A number found the first result in No. 2, but went astray in finding the molecular weight when the volume of a liter was given. Failure to solve for per cent was the principal error in No. 19. The chief difficulty in No. 14 was the failure to subtract 142 from 180 before dividing. In No. 6 some did not differentiate between liters and grams, a few did not balance the equation correctly, while some forgot the weight of a liter of hydrogen. The formula gave the most trouble in No. 1. In No. 17 some forgot the small ring of two around the nucleus, putting eight around and having four left for the valence. The equation presented the main difficulty in No. 8, some putting $NaSO_4$ instead of either $NaHSO_4$, or Na_2SO_4. A few had the proportion of the atomic weights stated inversely. No. 7 was given at the midyear examination. It was the same type as No. 10, but many had forgotten the method of solution. In No. 4, the formula for potassium chlorate proved to be the stumbling block for many, while the atomic weight of potassium had been forgotten by others.

In summing up the difficulties of rather typical problems, as shown by the tests, the main defects are: purely mathematical mistakes, lack of memorizing details, and lack of clearness in thinking. The mathematical mistakes are largely in decimals, direct and inverse proportion, and percentage. The above difficulties suggest several questions. How much mathematics should the chemistry teacher have to teach? How many details should the pupils be asked to memorize? For example, how many atomic weights? How many kinds of problems should the lower half of the class be able to think through clearly?

EQUATIONS.

The equations are stated exactly as they were given to the students in the tests.

Equations	Percent Error
1. Ionic equation of magnesium sulphate and barium chloride	97.2
2. $FeSO_4+NaOH$	80.5
3. $Ca(OH)_2+Al_2(SO_4)_3$	80.5
4. $Na_2S+CaCO_3$	73.6
5. Na_2O_2+HCl	73.6
6. $Al_2(SO_4)_3+NH_4OH$	72.9
7. Decomposition of potassium chlorate by heat	72.2
8. Na_2CO_3+HCl	69.4
9. Reaction of silver nitrate and calcium chloride	64.
10. Reaction of HCl on sodium carbonate	64.
11. Reaction of potassium on water	57.3
12. $CrCl_3+AgNO_3$	51.4
13. $AgNO_3+CaCl_2$	51.4
14. Action of calcium on water	51.4
15. $Zn+HCl$	44.6
16. $BaCl_2+AgNO_3$	44.6
17. Reaction of sodium hydroxide and magnesium sulphate	44.1
18. Solution of sodium carbonate and calcium sulphate	36.7
19. Reaction of lime water and carbon dioxide	35.3
20. Slaking of lime	32.3
21. Reaction of oxygen and hydrogen to form water	27.4
22. $KCl+AgNO_3$	27.
23. Heating calcium hydroxide	23.5
24. Heating limestone	22.
25. $Zn+N_2SO_4$	20.3
26. $NaCl+AgNO_3$	20.3

Numbers 6, 12, 13, 15, 16, 22, 25, and 26 were given while the class was studying equations. Remembering the valence and juggling the metallic, and non-metallic radicals proved to be the greatest obstacles. A few balanced No. 26 and got ClAg instead of AgCl. No. 6 proved to be the most difficult in this group. Numbers 2, 3, 4, 5, and 8 were given a month later with results that were poorer than before. The group, 1, 7, 9, 10, 11, and 21, was given in the midterm test with results that were about the same as in the previous tests. The ionic equation, No. 1, was balanced by many, but they failed to observe that $BaSO_4$ was thrown down as a precipitate and was non-ionized. Numbers 14, 17, 18, 19, 20, 23, and 24 were given later in the term, showing that a little improvement had been made, especially in the ability to write the formulas when the equations were written in this manner.

Formulas.

Two tests were given on formulas. The valence was given in one and not in the other.

Compound	Formula	Percent Error
1. Ammonium nitrate		70.
2 Aluminum sulphate		64.
3. Sodium sulphate		64.
4. Calcium phosphate		62.6
5. Sodium hydroxide		50.

6. Calcium carbonate	38.
7. Ferrous sulphate	34.
8. Aluminum phosphate	32.
9. Potassium iodide	21.3
10. Hydrochloric acid	9.5

Valence.	+ Li,	++ Mg,	+++ Al,	− Br,	−− So_4,	−−− Po_4

Give correct formula.

1. $AlSo_4$	15.2
2. $MgPo_4$	12.5
3. $LiPo_4$	9.7
4. AlBr	8.3
5. $LiSo_4$	6.9
6. MgBr	5.6

A comparison of these results shows that where the valence is given, little difficulty is encountered. The valence, and some of the radicals appear to cause the most mistakes. Numbers 1, 3, and 5 in the second list were repeated at the end of the year with an average of 5% greater error. Valence is largely a matter of association and memory. A large part of the students committed to memory the common valences for the time being. The bi-carbonate radical proved the most difficult and continued to bother many throughout the term.

Word Equations

	Percent Error
1. Sodium + water	67.1
2. Sodium chloride + hydrogen sulphate	53.9
3. Zinc + hydrochloric	32.9
4. Iron + chlorine	22.3
5. Zinc + sulphuric acid	19.4

Word equations were used before the formula equations were introduced. The results were better than with formulas. The majority of the students became able to write word equations so that they were dropped and the formula equations used in place of them. However I believe that they should be used to some extent throughout the entire year, especially with students who do not expect to study more chemistry. The main difficulty with word equations is in the nomenclature of the products.

Solutions.

Question	Percent Error
1. The rate at which a solid dissolves depends on ....., ..., and	60.5
2. An.....substance is one that loses water of crystallization on exposure to the.....	38.1
3. Water may be purified by....., ..., and.....	34.2
4. Potassium nitrate is more soluble in hot water than in cold.....	31.4
5. Potassium nitrate will dissolve faster at 60 C than sodium chloride.....	30.2

6. Large crystals will result from slow cooling	27.6
7. An efflorescent substance is one that will absorb moisture from the air	26.
8. A rise in temperature increases the solubility of gases in a liquid	23.6
9. A liquid used to dissolve a substance is called a solute, emulsion, solution, or a solvent	13.7
10. Salt dissolved in water raises, lowers, or does not change the freezing point of the solution	0

The per cent of error is about the same as for dissociation. Numbers 1, 2, 4, 6, 7 and 9, were questions that the student should have been able to answer from his own observation in the laboratory or from the class demonstration. The high per cent of error in No. 1 and No. 3, was due to the fact that it was not counted right unless all blanks were filled correctly. No. 10 was evidently too easy a question, for not one student missed it.

VALENCE.

Element	Percent Error	Element	Percent Error
1. bicarbonate	56.1	11. silver	26.
2. nitrate	52.	12. zinc	24.
3. hydroxide	35.6	13. sulphate	24.
4. chromium	35.6	14. mercury ic	23.2
5. ammonium	34.	15. calcium	23.2
6. barium	32.	16. aluminum	19.1
7. phosphate	32.	17. copper ic	19.1
8. carbonate	28.5	18. lead	17.8
9. magnesium	28.5	19. potassium	13.7
10. iodine	26.	20. iron ic	8.

The error is about 17% less on the average than in formulas. More drill was given to the students after this test. As a result, a large number memorized the common valences.

DISSOCIATION.

Questions	Percent Error
1. Cations move away from the cathode	50.
2. Concentrated acids are those which are highly dissociated	46.5
3. Reactions go to an end through....., ..., and	46.5
4. The addition of sodium acetate to acetic acid decreased the hydrogen ion concentration, increases the hydrogen ion concentration, neutralizes the acid, or has no effect	35.6
5. Sugar solution is a.....of electricity	35.6
6. A concentrated acid is one that is highly dissociated	27.
7. Acids furnish hydroxyl ions in a solution	24.3
8. The reaction of sodium chloride and sulphuric acid goes to and end through volatility, insolubility, or non-ionization	23.6
9. All acids contain O, Cl, Na, H, or N	17.8
10. Acids when in solution form ions of oxygen, hydrogen, metals, non-metals or hydroxide	17.8
11. All hydrogen ions carry a positive charge	16.4
12. The valence of an ion is equal to the number of charges carried by it	12.1
13. A solution of hydrochloric acid, of sugar, of alcohol, or of acetic acid is a very good conductor of electricity	6.7
14. Copper ions are green, blue, yellow, pink, or orange	5.7

The percentage of errors on this type of questions is much less than on the problems, equations, and formulas. Numbers 14 and 13, which had been demonstrated before the classes gave the best results. The high percentage of error in No. 3, was due to the fact that it was not called correct unless all three blanks were filled. A good part of the class had two filled correctly.

ATOMIC THEORY.

Question	Percent Error
1. An atom is the smallest part of an element having the properties of the mass	34.2
2. A physical change is one in which the structure of the molecules is altered	19.1
3. An..... is the smallest piece of an element that takes part in a.....change	15.8

There were scarcely enough questions asked on the atomic theory to give a very reliable estimate of their difficulty. Some students have difficulty with the difference between the atom and the molecule. There were a number of other difficult topics listed by the pupils, about which there were no data available for analysis.

In the summary which follows, the difficulties according to the data obtained from the tests, are ranked according to the average per cent of error. The difficulties of the first and second semesters, as ranked by the pupils, are placed opposite.

SUMMARY.

Difficulties	Percent Error	Rank 1st Sem.	Rank 2d Sem.
1. Problems	52.	3	2
2. Equations	49.	1	1
3. Formulas	44.5	4	4
4. Word equations	38.7		
5. Solutions	28.5	6	
6. Valence	27.7	2	3
7. Dissociation	26.1	5	
8. Atomic theory	23.		
9. Formulas (valence given)	9.7		
10. Organic chapter	No data		5
11. Theoretical parts	No data		6
12. Colloids	No data		7
13. Properties of elements	No data		8

The results in the final summary do not appear at all flattering. However the ranking of problems, equations, formulas, and valence is quite logical. Valence is largely the foundation upon which the others are built. Formulas require a knowledge of valence and symbols. Equations require formulas with the addition of balancing. Some of the problems require the bal-

anced equation along with the arithmetical operations to complete them.

The students ranked equations as the greatest difficulty at the end of each semester. This was probably due to the fact that more equations than problems were assigned to them.

A study of the two sections was made. These, as has already been stated, were sectioned homogeneously, according to their I. Q.'s. The median I. Q. of Section I was 103, and of Section II, 114. A comparison of the per cent of errors of the two sections is shown in the following table.

	Section I	Section II
Problems	61.3	44.2
Equations	64.8	42.
Formulas	56.1	34.5
Word equations	49.4	34.3
Solutions	29.6	22.5
Valence	35.9	19.8
Dissociation	36.4	21.7
Atomic theory	24.7	21.3
Formulas (with valence)	21.2	5.1

The average per cent of error of all difficulties in Section I was 42.2, and Section II, 26.7. The difference would probably have been even greater, if the six irregular pupils in Section II, whose I. Q. was below 100, had been in Section I. Thus it can readily be seen that the section with the higher I. Q. did better work. The above results would tend to support the reliability of the Terman Intelligence tests in forecasting the achievement of the pupils.

The third purpose in this study was to suggest methods of over coming the difficulties. Briefly, the suggestions are: (1) to teach less material; (2) to have material better adapted to the interests of the pupil; (3) to insist on more study; (4) to give more individual help; (5) to have closer correlation between class and laboratory work; (6) to have more frequent objective tests; and (7) to section according to the I. Q.

One difficulty, that is too often overlooked, is the crowding of too much material into the chemistry course in the time that is given to teach it. Most authors, in making a revision of their text book, add a new chapter or two, but never eliminate anything. From the above summary, it would seem that only a minimum amount of organic chemistry should be given. The same would be true of the description of some of the elements and their compounds. Colloids, the periodic system, and radioactivity might well be omitted or used only for supplementary

work. With the elimination of this material, more time could be given to the essential parts of chemistry.

It was found, in a separate study of the chief interests of the pupils, that only twelve would necessarily need to study more chemistry in their college work. However, of the forty-three students, who expected to go to college, thirty said that they would like to take more chemistry. Thirty-five of the boys took an active part in a Science Club, which held bi-monthly meetings. In question No. 3, concerning the most interesting parts of chemistry, the majority said that the laboratory work was most interesting. The study of the elements ranked second. Sulphur was third, probably because it had just been studied at the time the question was asked. Class demonstrations came fourth. To a few there was a fascination in writing equations. The large list of answers shows how broad the interests are in the different phases of chemistry. The question might arise, "Should the things most interesting to the students be emphasized?" If so, how?"

In answering question No. 2 of the questionnaire, twenty-nine pupils stated that more study would have made the difficulties easier. A number of these pupils spent too much time on extra-curricular activities, especially literary contests, dramatics, and athletics. Seventeen students said that they spent more time in preparing chemistry, sixteen less time, and thirty-eight about an equal amount of time as compared with their other studies. Another factor is the downright laziness of some pupils. Their chief ambition seems to be to do just as little work as they can, and still be able to pass. The twenty-eight that said chemistry was "naturally difficult" told the truth as far as they were concerned. The other pupil answers are suggestions that are worth some consideration.

Another difficulty encountered in teaching the course was the inability to give much individual help. This was due to the large classes, and otherwise heavy schedule of teaching. On account of differences in pupils, many needed individual help to secure the best results.

Many pupils did not seem to be able to remember the results of experiments done in the laboratory when asked in regular tests. In other words, they did not correlate their laboratory work with class work to the degree that one would expect. A few people had difficulty in interpreting their laboratory manuals. This was nearly always true if the experiment was of a quantitative nature.

Frequent "home made" objective tests should be given in order to diagnose difficulties and measure achievement. The ease with which they may be scored, well repays the time it takes to make them. Pupils like to take them. Seventy out of seventy-two pupils said they would rather take the objective type tests than the essay type. The previous year, there was only one out of seventy-five pupils who preferred the essay type. In the words of Morrison, one should "Teach, test, and teach again," if mastery is to be obtained.

ARCTIC GETTING WARMER.

That the Arctic climate is getting warmer, at least temporarily, is indicated by studies made by the U. S. Coast Guard's expedition to the waters between Labrador and Greenland, and which has just returned after an absence of over two months. One of the purposes was to measure ocean temperatures in this area, and by this means they found that a surface layer of water 100 meters in thickness, covering an ocean area of 100,000 square miles, was five degrees warmer than normally. "Such an additional heat reservoir of tremendous proportions is bound to have far-reaching climatic effects," pointed out Commander Edward H. Smith, who commanded the expedition.

Other important conclusions reached as the result of the expedition were as follows:

The bottom water in the trough between Greenland and Labrador has a temperature of 37 degrees Fahrenheit and a saltiness of 3.49 per cent. "The observations showed," said Commander Smith, "that this water was not produced on the surface or by melting ice, as suggested in theories of Nansen and Pettersson, but indications point to a slow bottom creep from the Antarctic as the source of such waters, even off Greenland."

The coastal shelves of Greenland are much narrower than shown on present day maps, while the Labrador shelf is wider.

Three headlands were sighted by the Marion north of 60 degrees latitude, which indicate that the coast of Baffin Land, as shown on maps, is in some places as much as 20 miles in error.

The Arctic waters were extremely open this summer. About a thousands bergs in Disko Bay near the glacier front and 200 bergs stranded on the Labrador Coast near Cape Harrison, constituted practically the only ice present. The Arctic pack itself shrank to 20 miles off Cape Dier, Baffin Land.

In telling of the experiences of the expedition Commander Smith related the excitement they had in a severe gale. Another exciting experience was when the polar bear cub which they captured, and which has now been sent to the Washington zoo, escaped from his hold and tried to fight his way to freedom. The chief casualty, however, was the back of Commander Smith's coat, which the bear clawed. But the members of the crew were not entirely without recreation, for they had dances with Eskimo maidens and at Godhavn played a soccer game with an Eskimo team. The score was 28-0, in favor of the Greenlanders! —*Science News-Letter.*

A STUDY OF THE VAN WAGENEN READING SCALES, GENERAL SCIENCE.

By M. Eustace Broom,

State Teachers College, San Diego, Calif.

Ability to comprehend the meaning of the printed English language, read silently, is of considerable importance in high school study if, as Starch says, " . . in the high school and the university probably two-thirds of all studying consists essentially in reading."[1] Of considerable interest is Symonds' comment that it may be that reading ability is specialized in the high school according to the type of content.[2] There is little objective evidence to support this opinion. However, Van Wagenen has devised scales[3] for measuring ability to read specialized high school subject matter. These are essentially prognostic tests in the different high school "reading subjects."

The Van Wagenen Reading Scales, History A and B, have been discussed by Murdock as follows: "The Van Wagenen History Reading Test . . . is not intended as a means of mastery of historical content, but is, as its name implies, a measure of ability to read historical materials. . . . The Van Wagenen History Reading Tests would seem to have a clear claim to the measurement of abilities other than pure knowledge of factual history."[4] Murdock bases his conclusions upon the results of statistical procedure.

The writer has attacked the same problem in an entirely different manner. Form A of the General Science Reading Scales was given at the beginning of two school years, 1925-1926 and 1926-1927, to 77 students in physics (2 classes), chemistry (1 class), and general science (2 classes). Form B of these scales was given to the members of these five classes about two weeks before the close of the school term. Approximately nine months intervened between the two applications of the test. During this time the students received definite instruction in some high school science course. It is of some interest to note that Form A of this test seems weighted somewhat toward biology, and Form B, toward physics and chemistry.

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[1]Starch, Daniel. "Educational Psychology, Revised Edition." New York, The Macmillan Co., 1927. Page 194.

[2]Symonds, Percival M. "Measurement in Secondary Education." New York, The Macmillan Co., 1927. Page 109.

[3]Van Wagenen Reading Scales, General Science A and B; History A and B; English Literature, Alpha, Beta, A, B, and C. Published by Public School Publishing Company.

[4]Murdock, J. R. "Critical Studies of the Standardized Tests in the Social Studies for High Schools." In Ruch, et al. "Objective Examination Methods in the Social Studies." Chicago; Scott, Foresman and Company, 1926. Pages 108 and 110.

Mental age data was obtained by using the Terman Group Test of Mental Ability during the first school month of each year. Form A was used in 1925-1926 and Form B in 1926-1927. The mental age equivalents for point scores were computed as of the date of giving each form of the Van Wagenen test. This was possible because the I. Q. measures yielded by the Terman

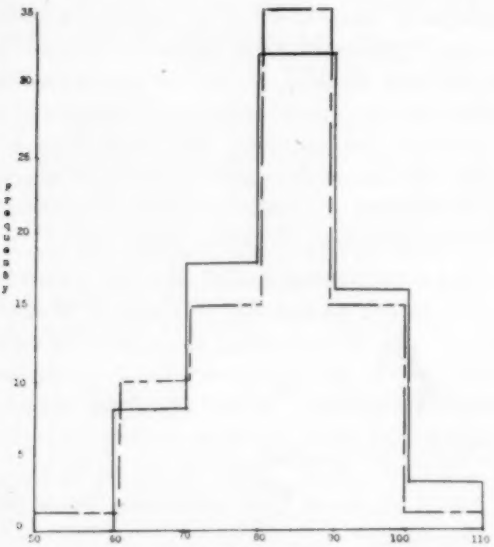


FIGURE 1. DISTRIBUTION OF SCORES FROM TWO APPLICATIONS OF THE VAN WAGENEN READING SCALES, FORMS A AND B. 77 CASES. THE BROKEN LINE REPRESENTS THE DISTRIBUTION OF SCORES ON THE FIRST TEST; THE SOLID LINE, SCORES ON THE SECOND TEST.

Measure	Scores on V. W. test, Form A	Scores on V. W. test, Form B	Terman Mental Age (I)	Terman Mental Age (II)
Range	56–101	66–106	13–4 to 19–2	14–1 to 19–11
Mean	81.45	80.60	16–2*	17–1*
Probable error of mean	1.0	1.09	0–2*	0–2*
Standard deviation	8.72	9.60	1–7*	1–9*
Coefficient of variability	10.70	11.91	9.28	10.24

*These units are expressed in years and months of mental age to the nearest whole month.

Table 1. Measures calculated for the several score distributions. 77 cases.

test are highly constant.[5]

The distributions of scores from the application of the two Van Wagenen tests are shown graphically in Figure 1. Table 1 presents the measures of central tendency, of unreliability, and of variability of the several score distributions.

The relationship existing between the several series of scores when paired is shown in Table 2.

Measures compared	Number of cases	r (Pearson)	P. E.	k (Kelley)
Van Wagenen Reading Scales, Form A with Form B	77	.846	.022	.533
V. W. R. S., Form A with Terman M. A.	77	.625	.047	.781
V. W. R. S., Form B with Terman M. A.	77	.597	.049	.802

Table 2. Measures of relationship (r) and of lack of relationship (k) of the paired series of scores.

FINDINGS:

1. These findings should be considered as tentative as they are based on 77 cases only.

2. The Van Wagenen Reading Scales, General Science A and B, seem to measure comprehension of scientific content printed in the English language when it is read silently rather than other variables.

3. These reading tests should not be used as a measure of effectiveness of instruction, since pupil scores seem little subject to improvement through scientific study. The average score in both testings barely exceeds the norm for ninth grade pupils, 80.

4. These tests seem reliable measuring instruments. No study of validity has been attempted.

[5]Broom, Eustace. "Constancy of the I. Q." School and Society, 25: 295-6. March 5, 1927. Broom, M. Eustace. "A Study of the Constancy of the I. Q." Educational Research Bulletin (Los Angeles), 7: 2 and 3: 2-4. October-November, 1927.

WHALE MISTAKEN FOR SHIP.

The enormous skeleton of a 5,000-year-old Greenland whale has been found at Kistinge, near Halmstad, Sweden, by workmen digging a ditch near the seashore. A monstrous jawbone, measuring about 13 feet in length, has already been unearthed. On account of its size, it was first taken by the workmen to be a part of the hull of an ancient vessel.

The bone has been examined by paleontologists, who estimate the whale to have lived at the end of the ice age, about 5,000 years ago.—*Science News-Letter.*

IS MATHEMATICS JUST HARD SENSE?

By Louise M. Essex,
Long Beach, Calif.

In one of Booth Tarkington's short stories, "Beasley's Christmas Party," I found this conversation:

"Did you know Miss Ann Apperwaite was a teacher of mathematics?"

"Yes," said Mrs. Simeon Peck wisely, "I always thought that explained it; the romance is a reaction from the algebra. I never knew a person connected with mathematics or astronomy or statistics or any of those exact things who didn't have a crazy streak in 'em somewhere. They've got to blow off steam and be foolish to make up for putting in so much of their time at hard sense."

The thought came to me—Is mathematics just hard sense? Cannot one find in the subject adventure, romance and a suitable occasion for the play of the imagination? How could the ancient Greeks have taken such a delight in mathematics? Was Greece a nation with all of its love for beauty in art and poetry, and its enthusiasm for games and sports to be satisfied with just hard sense?

The ancient Greeks seemed to love all of the things that youth demands. Edgar James Swift in his book of Youth and Race, says, "The young boy and girl will be active, they insist upon adventures, and they are bound to show off."

Do algebra and geometry have the capacity to give to the youth what he demands? Like savages, children are both readily entertained and easily bored. Life must be spirited or they will break its bonds and find their own adventures. We know that adventures need not be spectacular to meet the requirements; the imagination, which is such a dominant factor in youth, helps solve the problem amazingly.

An assignment to search through the parks, or the theaters, or churches, or the dress shops to find the number of places geometric figures are used within their premises will furnish enough adventure for any live American youth.

It may not be as exciting as duck hunting or football, but there is novelty in the adventure.

The young girl and boy are suddenly overwhelmed with the fact that they are in a world of geometric figures. One finds nature itself made up of geometric design. What would the architect, the artist or the designer do without geometry?

There is always an unexpected aliveness in an abrupt awakening, and the boys and girls feel this when they suddenly realize that they are surrounded by squares, triangles, spheres, and circles.

When the new Orpheum Theatre opened its doors, Omaha was delighted with the beautiful new building. My geometry students were greatly pleased to report to the class the results of their exploration of the building. James had discovered more geometric figures than John, hence he was the one to receive the greatest recognition.

The same spirit of adventure and the same innate love to show off manifested themselves in the search through the buildings of Omaha as in the attempts to fly across the Atlantic—it is the spirit of youth.

The girls thrill over the attendance at style shows and the discovery of geometric figures used in costumes. The quaintness of a search in quarters dear to every girl's heart makes a satisfactory appeal.

I find I get the best results by having these reports written. It makes a more definite assignment. Moreover, men and women usually make official reports of their important adventures. Didn't Lindbergh write a book?

However, with only an appreciation of geometric figures which furnishes all possible play to the imagination, one would not necessarily be a creditable student of geometry. The youth must be taught to reason and reason logically.

Can we find a place in the world of pleasure and entertainment where this same reasoning is used—a place outside of the world of cold facts?

Robert Barr, in the Bookman, March, 1897, says about the plot of the short story:

"My model is Euclid, whose justly celebrated book of short stories, entitled 'The Elements of Geometry,' will live when most of us who are scribbling today are forgotten. Euclid lays down his plot, sets instantly to work at its development, letting no incident creep in that does not bear relation to the climax, using no unnecessary words, always keeping his one end in view, and the moment he reaches the culmination he stops.

As all boys revel over detective stories, stories of exceptionally well constructed plots, can they not be made to realize that the same reasoning is used in proving geometric theorems as in their intriguing detective stories?

We will now turn our attention to algebra. Can the youth be made to feel that it has the warmth and charm of pulsating life?

We often hear about the boy of today. He neither respects nor obeys. He is growing up without any respect for law or feeling of responsibility or you may have heard it stated in this manner: Disregard for law is fast becoming an American characteristic.

Let us take the simple equation in algebra. The youth, through carelessness or ignorance, adds something to one side of the equation and not to the other side. He goes through the solution of the problem. What happens? He gets the incorrect result; the problem will not check.

He has disobeyed a law, either through lack of concentration or ignorance; the reason is of no concern, but the fact remains that he has failed to obtain the correct result.

All of this happens before his very eyes, and the significance of the law can be easily felt.

Is not all of life made up of laws—physical laws, moral laws, and spiritual laws?

The laws of the universe are there for us to use—we fail either through carelessness or ignorance but again the reason for our failure is of no importance.

Is there any place where the young people of today, through subtle and tactful suggestion, can be made to feel more keenly the unconquerable, powerful force of law in life than in algebra?

Short speed tests in the fundamentals of algebra add zest to the course and will always bring enthusiasm and close concentration; especially in a class composed of boys. Boys love games and they show the same degree of interest in a competitive speed test in algebra as in a game of checkers or chess.

Booth Tarkington has said what so many think—they think it probably because Booth Tarkingtons have said it, but the fact is that mathematics furnishes plenty of adventure and play for the imagination to satisfy any youth; at the same time it is teaching them the principles of logical reasoning and still more important perhaps—an awed respect for law.

Does any other subject furnish more of the requirements of youth or of life itself?

Mathematics trains for sane, well balanced citizenship, and can we ask more of any experience in life?

A PRACTICAL PLAN FOR A CHEMICAL INSPECTION TOUR.

By Ralph E. Dunbar,

Dakota Wesleyan University, Mitchell, S. Dak.

The author taught classes in chemistry for four years in a typical small town where the industries that might be visited and studied were limited to a bakery, rather inefficient water supply system, a still cruder sewage disposal plant, a transformer station, and a flour mill. There were, of course, the usual blacksmith shops, garages, groceries, hardware stores, and other places of business where some material of importance could be obtained. There are hundreds of other science teachers laboring under similar or even greater distressing conditions today. However, we were fortunate in having an unusually liberal supply of the average apparatus and chemicals. We made frequent use of industrial and government movies. A number of splendid industrial exhibits were at our disposal. And yet under these conditions we often felt our extreme limitations in not being able to visit more places where chemical reactions were carried out on a commercial scale.

At present the author is more favorably located in a flourishing college town of ten thousand people. There is no serious lack of essential or even desirable apparatus or chemicals. We have the usual projection machines, and an even greater assortment of industrial exhibits. The laboratories and general arrangements are equal or even superior to those usually found under similar conditions. However, there is that same lack of industrial plants for careful study and visitation. The list, while somewhat more extensive than the former, is still limited to three creameries, a laundry, a modern water and sewage disposal plant, two printing offices, a railroad water softening plant, a bottling works, three cleaning establishments, a gas plant, a power plant, automatic telephone exchange, three bakeries, a candy factory, flour mill, and three ice cream factories. This might seem like a rather extensive list and yet it offers little variety and limited possibilities. After visiting the plants available we have felt the need of something more extensive and offering greater variety.

However, we are located seventy-four miles from the largest city in the state and one of the largest and most important industrial centers of this section. For the past three years we have made an annual pilgrimage to this city and have met with such

remarkable success that we feel justified in recommending this plan to other instructors similarly located. Considerable work is involved in first outlining the itinerary and other details but once such details have been completed they can be followed from year to year.

Our plan of procedure, originally, was as follows: We secured a list of all wholesalers and manufacturers from the Secretary of the Chamber of Commerce of the city to be visited. A tentative program with suitable plans for hours and places to be visited was then drawn up. An instructor in the department several weeks in advance visited these same plants, arranged for the class visit, consulted the guides to be provided, and secured the necessary data for outlining suitable study plans for the students to use on the visit. Needless to say, a number of changes in the original plans were necessary before the full schedule assumed final form. Likewise, it might be added that all these preliminary details were easily disposed of by regular correspondence after the first visit. Usually outlines, schedules of hours, and other details suitable for one year can be repeated the following year, at least with minor variations.

When the date has been arranged for the excursion, and all necessary arrangements made with the managers of the plants to be visited, a check is made in the several chemistry classes as to the number of students that expect to make the trip and a small deposit is charged to guarantee the presence of the student on the morning of the excursion. Highway buses are then chartered for the use of the group. We have been able to secure cheaper rates than by rail, and also have the buses at our disposal while in the city. In case the buses are not completely filled we have always found that students from the physics, biology, home economics or other science departments are very eager to utilize any available seats and join the group.

The buses usually leave at 6:00 a. m., arriving at approximately 8:00 a. m. One hour is given for breakfast and relaxation, and the first plant is entered at 9:00 a. m. The period from 12:00 m. until 1:00 p. m. is also a rest and luncheon period. The plants are visited in rapid succession, as fast as conditions will permit. A set of mimeographed questions is given to each student before he enters each plant, emphasizing the most essential details. We have usually included only plants that are not available in our home community. Among those usually visited are a typical packing plant, cooky and cracker factory,

clinic, twine factory, lithographing plant, engraving plant, iron and aluminum foundry, and artificial ice plant.

At 5:00 p. m. the students assemble in the city park for a picnic lunch. A show may be included for the evening's entertainment, if the group still possesses enough of their original enthusiasm and vitality. Added interest and enthusiasm may be gained by a liberal use of pennants and banners on the buses used. The complete necessary cost of our last excursion was $1.89 each for transportation and the price of three meals which was entirely in the hands of the individual students. The cost is small in comparison to the benefits received in added interest, enthusiasm, and information.

DESIRABLE QUALITIES IN DEMONSTRATION EXPERIMENTS.

At the May meeting of the Eastern Association of Physics Teachers, Professor A. W. Duff enumerated the following desirable characteristics for demonstration experiments:

1. Apparatus should be on a large scale.

Use of ping-pong balls painted with aluminum, instead of pith-balls in electrostatics.

Long wire carrying current cutting across field of large electromagnet.

2. Apparatus should be as simple as possible.

Resonance in pendulum with spring for suspension.

3. Experiment should stimulate further thought.

Cutting of ice by two wires of different substances, same size, at different rates. Why?

4. Positive effects, or motion, more impressive than null effects, or rest.

Temperature loss of magnetism in iron and nickel shown by pendulums, magnet, and lamps.

5. Slight dramatic element sometimes useful.

Salt vs. sugar, sulfuric acid vs. glycerine in electrolysis. Each pair of substances is similar in *physical* qualities.

6. An element of the unexpected sometimes effective.

Angular momentum with changing moment of inertia—the principle on which a cat or a gymnast turns in the air.

7. Experiment should illustrate principle of some importance.

Heat transformable into mechanical energy—but only partly (Griffiths' experiment).

8. Speed of action should be suitable.

Why setting or rising sun is red (Sodium thiosulfate, hydrochloric acid).

9. Experiment should be as nearly infallible as possible.

Vibrating rods of wood to show principle of harmonic motion and Hooke's law of elasticity.

NATURE'S GREAT AND SMALL AND MAN'S MEASUREMENT OF BOTH.

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

Part 1. Mass.

Man stands midway in the universe. Through a telescope he looks up at the vastness of nature and through a microscope he looks down at its minuteness. The two vistas are of nearly equal extent and complexity. It is an interesting fact that the sun and stars are about as many times more massive than a man as the atoms are smaller. It would require ten to the twenty-eighth power human bodies to weigh as much as a small star, and ten to the twenty-seventh power atoms make a human body.

Scarcely had the present century opened when enterprising scientists became tired of regarding the atom as an indivisible entity and began picking it to pieces as an enquiring child pulls the petals from a flower, and scatters its pollen.

The parts of the atom have been compelled to submit to having their measurements taken, and if not their finger prints, at least their erratic movements as they flit about in front of a photographic plate.

As in the naming of a new baby several appellations are often tried before one is found that seems to be fitting so it has been with the newly discovered particles that make up the atom. They were first called "primordial atoms." Later this ponderous designation of a thing so small gave way to the name "corpuscle," signifying simply "a little body." Now that more is known of the nature of the atom's constituent parts, the center piece, which comprises most of the mass of the atom but takes up very little room, is called the "nucleus," and the lighter and more active particles that race with each other around the nucleus, each carrying a charge of electricity, are called "electrons."

A new conception of the atom has been suggested by Schrödinger, and is receiving marked attention by scientists. The following discussion of the atom, however, is based upon Bohr's theory, which regards it as a sort of solar system.

If size were a measure of importance neither nucleus nor electrons would be very essential to the wellbeing of an atom, for the electrons are about one sixty thousandths the diameter of the whole atom, and the nucleus is, if anything, still smaller.

Since the electrons are so small in proportion to the size of the atom, and their number in the different atoms varies from only

one to no more than ninety-two it will be seen that most of the atom is empty space. The amount of available room in which electrons can move around within the atom is about as great proportionally as the amount of empty space among the planets of the solar system.

The importance of the electrons seems to be due to the energy they possess as exhibited by their activity. Certainly in this respect nothing can be said to be wanting. The one tiny electron of an atom of hydrogen makes up for other deficiencies by circling about its nucleus at the rate of fourteen hundred miles a second.

It may be asked by the thoughtful reader, "How can scientists time so high a speed of an object they cannot see?" The answer is simple. They make use of exactly the same logic that Kipling used in accounting for the great speed of the Kangaroo, in the exercise of which he developed his long hind legs. Yellow Dog Dingo was after the Kangaroo, and he *had to* run.

The Dingo of the electron is the positively charged nucleus, which threatens at any moment to draw the electron from its orbit, ending its career in a disastrous nose dive. Thanks to Dr. Millikan the negative charge of the electron is known, and therefore the amount of centrifugal force needed to hold the revolving electron at a respectful distance from the nucleus can be calculated. The speed necessary to develop this amount of centrifugal force is found to be fourteen hundred miles a second, Q. E. D.

The same principles used in the measurement of atoms are also used in the measurement of stars. The sun, the particular star of our system, has a mass of three hundred and thirty thousand times that of the earth. If the sun were put into one pan of a balance the earth would be scarcely more than a little dust in the other pan. The seeming difficulty of weighing the sun vanishes with the application of some of the same magic applied to the measurement of the speed of the electron in its orbit.

In this case we know the velocity of the earth about its "nucleus," the sun, and can therefore calculate the gravitational pull which the sun must exert to keep the earth from flying off on a tangent to its orbit. This force, according to Newton's law of gravitation, depends upon the sun's mass and its distance The distance being known it is a simple matter of arithmetic to compute the mass to be, as stated, three hundred and thirty thousand times that of the earth.

But since the average reader is not accustomed to weighing articles so large as the sun, and since the problem is so fundamental a one in science a few details of manipulation might not be amiss.

It will be remembered that Sir Isaac Newton is said to have watched an apple in its fall from a tree, and being an idealist rather than a "practical man," the thoughts that entered his mind did not concern themselves with the eating of the apple. He rather considered that if the apple, being four thousand miles from the center of the earth, fell sixteen feet in a second, the earth, being ninety three million miles from the sun should tend to fall a certain distance toward the sun each second.

Newton of course knew that the earth goes eighteen and five tenths miles a second in its orbit, and he was able easily to calculate that the curvature of its orbit is so slight that the curved line and the tangent to it part company only one ninth of an inch in the distance traveled by the earth in a second.

An automobile driver who could run eighteen and five tenths miles in the snow and have his track curve but one ninth of an inch would consider himself a straight driver, but this is what the sun does. This fraction of an inch is the amount the earth falls away from a tangent because of the sun's attraction. When compared with the sixteen feet that the apple falls (and distances to the centers of gravity are taken into account) the attractive force of the sun, and therefore its mass, is seen to be the amount given above.

What of the stars? Are they as massive as the sun? There is a popular misconception that they are much more so, but our sun is little if at all smaller in mass than are the average stars. To be sure some of the stars contain many millions of times the *volume* of the sun, but these are made of rarefied gases. If we were within the star of Antares, which is larger in diameter than the orbit of Mars, we would suffocate for lack of air to breathe, even though its composition and temperature were suitable. It is lighter than a fairly good vacuum.

But in mass there are only a few stars known to be as much as ten times as heavy as the sun. The heaviest stars known are two companions, recently discovered, that go around their common center of gravity. This double star is very unusual. The mass of each component is about seventy times that of the sun.

Only double stars can be weighed. The mass of those having no companion can merely be estimated by certain characteristics. But since a considerable proportion of the stars are double the sampling of star masses is very satisfactory.

Mass determinations of the sun, moon, planets, and stars are all made in terms of the mass of the earth. Unless this is known the masses cannot be stated in ordinary units such as pounds or tons.

It might be thought an easy matter to weigh the earth by simply taking a cubic foot of rock of average density and weighing it, and then multiplying the result by the number of cubic feet in the earth. But second thought shows the possibility of the inaccessible center being much denser than the surface.

The only way in which the earth's mass has ever been found is by setting up a miniature earth, and comparing the attraction which it exerts with the attraction that the earth exerts.

The most recent and most refined experiment of this sort is the one which Dr. Paul Heyl has for the past three years been carrying on in a laboratory of the U. S. Bureau of Standards at Washington.

The miniature earth used is an iron cylinder weighing one hundred and forty pounds. Its attraction is exerted on a little platinum ball attached to a torsion balance. Two such iron masses are used, and two platinum balls so that the effect will be increased. Even then the pull to be measured is a force no greater than the weight of the ink in a period of print.

Expressed in tons the mass of the earth is found by such experiments to be about six with twenty-one ciphers attached. Expressed in terms of the mass of an equal volume of water it is about five and a half.

Since the density of surface rock is from two and seven tenths to three, it will be seen that the interior of the earth must be very heavy in order to make the average as high as five and a half. The conclusion drawn from this is that for about two thousand miles out from the center of the earth, its composition is solid iron.

The composition of meteorites, the rate at which earthquake shocks travel through the earth, and other considerations lead to the supposition that the earth is ballasted with iron rather than with gold or other heavy metal.

From the mass of a star to the mass of an electron is as great a transition as from Milton's Paradise to Dante's Inferno. But

the same laws hold for star and electron. If we could divide 1.66 grams of matter into as many parts as would be equal to one with twenty-four ciphers attached each part would weigh as much as the nucleus of a hydrogen atom. That seems small, but it is 1845 times as much as an electron weighs.

This is the bottom of the downward plunge from the star into the infinitesimal. At least science has not yet succeeded in subdividing the electron.

To find the mass of an electron it was first necessary to find the amount of electricity it carries, its charge. Several methods have been employed for this but Millikan's famous oil drop experiment has given the charge with extreme accuracy.

The problem of finding both the mass and velocity of electrons is something like the problem of finding the velocity of a bullet by shooting it in a horizontal direction, and finding how far it will go before striking the earth. The greater the speed of the bullet the farther it will go before the force of gravity can bring it to earth.

Electrons are shot off from the cathode of a vacuum tube and the stream is drawn aside by a magnet and also by an electrically charged plate. The sharpness of the electron's turn as it flies by the magnet depends upon its mass and velocity. These two unknown quantities can be found with the help of two algebraic equations, which would look out of place here, since we are merely discussing the fundamental principles.

The mass of this lightest particle of matter if expressed as a fraction of a gram is found by the above method to be nine divided by one with twenty eight ciphers in its wake.

Strange to say the lightest particle in nature is not the smallest. The diameter of the nucleus of a hydrogen atom is thought to be about one centimeter divided by one followed by thirteen ciphers. This smallest of all objects is measured by using it as a target and seeing how difficult it is to hit it.

Radium is perpetually shooting out nuclei of the helium atom. Its machine gun fire may be turned upon some gas or solid and by appropriate means of more than one sort the number of direct hits may be counted.

A hit means that the *nucleus* of an atom has been the target, for there is nothing else in the atom massive enough to stop a projectile.

If a person were to shoot into a flock of birds, the likelihood of one being struck would depend somewhat upon the size of

the birds. So with the atom. The projectile is found to pass through some tens or hundreds of thousands of atoms before it strikes a nucleus. The conclusion is that the nucleus must be very small.

NATAL, BRAZIL: SOUTH AMERICA'S "AIR DOOR."

Natal, Brazil, near which the late Major Delprete and Captain Ferrarin landed on their record-making flight from Rome, is the natural "air-door" to South America for all air traffic from Europe and Africa. It is close to Brazil's northeastern corner, the point of land which the New World thrusts nearest to the old.

The airplane and the radio, because of the locations of landing fields and broadcast stations, are making new geographic centers just as railroad junctions have done in the past.

Because of Natal's strategic geographic position in this regard the recently organized air-mail line between Paris and Buenos Aires has established a flying field near the town. Natal has also figured in Brazilian maritime plans, and its harbor is being improved with a view to making it the first port of call for steamships between Europe and ports on the southeast coast of South America.

Cape St. Roque may be considered the real northeast corner of South America. It lies approximately 20 miles north of Natal. The intervening strip of coast is made up of low sand dunes, with here and there a village set among the coco palms. Touros, where the second landing was effected when the flyers became lost in the fog, is about 30 or 40 miles north of Cape St. Roque.

Natal is not directly on the sea but lies about two miles up the river Potenghy, which is also known as the Rio Grande do Norte. It is from this stream that the state of Rio Grande do Norte, of which Natal is the capital, takes its name. The town was founded by the Portuguese more than three and a quarter centuries ago as a military post. In 1633 it was captured by the Dutch and remained in their possession until 1654. Few traces of the Dutch occupation remain.

Natal is far removed from the center of Brazilian activity in the south, and still has some touches of the frontier. Southward, railways along the coast connect it with Pernambuco; but only a short bit of trackage extends toward the interior. For the movement of goods to and from the back country the town still depends somewhat on picturesque troops of pack mules and horses in charge of a *tropeiro* and his swarthy, hard-visaged assistants.

Sometimes 100 or more mules and horses, each laden with big bags of cotton or other produce from the interior, thread their way through Natal's streets, with bells tinkling, and muleteers shouting—an animated freight train. On the return trip they carry bales of fabrics, food supplies, and household furnishings.

The muleteers of Rio Grande do Norte and the adjoining states must be a rough and ready lot, for the goods they carry are an irresistible temptation to bandits in the hilly interior, and often the drivers must "shoot their way through." The gradually extending lines of steel in the interior of Brazil are slowly bringing the existence of the picturesque *tropeiro* to an end.—*Geographic News Bulletin.*

BRIDGING THE GAP BETWEEN THEORY AND PRACTICE IN NINTH GRADE MATHEMATICS.

By Wm. Herbert Edwards,

Northeastern High School, Detroit, Mich.

You have but to compare educational theory with the educational practice found in any high school class familiar to you to realize that a distinct gap exists between theory and practice in the teaching of mathematics. Teachers are not applying in their classes any appreciable amount of the tested educational psychology available.

We are not concerned in this paper with causes. Our purpose is to show how this gap between theory and practice may be bridged in the mathematics class room by any teacher willing to make the effort. Two examples from ninth grade mathematics will suffice to illustrate how theory may be adapted to actual teaching situations.

Example I. Problem Material.

One of the theories of education supported by objective evidence is that the problem material in a mathematics text book should be within the social experience of the learner. How can the mathematics teacher apply this theory in his teaching?

The first thing the teacher has to do is to determine the social situations involved in the problem material in the text book he is using. This determination can be made by analyzing the problem material. For example, the writer analyzed the problem material in the text used by his first semester ninth grade mathematics pupils and found fifty-nine words or phrases having social connotation. Social connotation is involved in a phrase such as "500 acres" appearing in a problem. The text infers that students know the meaning of these words from previous experience in arithmetic perhaps.

The next step is to determine the extent to which the social experiences involved in the problem material are social experiences of the pupils in the class. This can be accomplished by testing the pupils on the words or phrases discovered by the analysis of the problem material.

The writer submitted to his beginning ninth grade pupils the fifty nine words and phrases representing social situations found in the problem material of the text book used in his mathematics classes. The results are summarized in Table I in evidence

that it cannot be taken for granted that the problem material in a text book is within the social experience of the pupils in a given class. For example, there were twenty words and phrases, almost 40% of the entire list, that from 51 to 60% of the class did not know.

TABLE I.—GROUPED PERCENTAGE OF FIFTY-NINE WORDS OR PHRASES HAVING SOCIAL CONNOTATION NOT KNOWN BY 69 PUPILS IN NINTH GRADE.

Grouping	Words or Phrases not Known
91—100% of pupils	1
81— 90% of pupils	2
71— 80% of pupils	4
61— 70% of pupils	5
51— 60% of pupils	8
41— 50% of pupils	8
31— 40% of pupils	5
21— 30% of pupils	5
11— 20% of pupils	14
1— 10% of pupils	7

The final step in attempting to use in the class room the theory that the problem material should be within the social experience of the learner is to provide for the class the social experiences that the class has not had and which are involved in the problem material in the text book. The results of the test just discussed will reveal the social experiences that need to be provided. In the event that any given social experience cannot be provided, then the teacher should not assign the problem or problems involving this particular experience.

EXAMPLE II. AIMS OF MATHEMATICS INSTRUCTION.

Another of the theories of education backed by ample investigation is that pupils should have "immediate and undisputed use of the fundamental processes," to use the words of the Reorganization Committee in listing the aims of mathematics instruction.

Obviously the first step in utilizing this ideal in ninth grade mathematics is that of determining the command of the fundamental processes existing in a given group of students. For example, the writer used the Monroe Diagnostic Tests in Arithmetic in his ninth grade classes. The results (summarized in Table II) show that the teacher cannot assume that his pupils in ninth grade have a reliable or a uniform command of the essentials of arithmetic.

The results of the diagnostic test are used to design a set of remedial self-testing drills. These drills would be changed from

TABLE II.—RESULTS OF MONROE DIAGNOSTIC TEST IN ARITHMETIC GIVEN TO SEVENTY-FOUR PUPILS IN NINTH GRADE.

Ability	Percent Rights
1. Adding single columns	82.4
2. Adding four columns	70.5
3. Adding fractions	55.2
4. Substracting whole numbers	92.6
5. Substracting fractions	53.7
6. Multiplying by a unit number	89.5
7. Multiplying by higher than unit number	73.4
8. Multiplying fractions	67.3
9. Pointing off decimal point in multiplication	94.0
10. Simple division	82.0
11. Long division	56.7
12. Division of fractions	35.7
13. Pointing off decimal point in division	42.9

time to time as improvement in one or more of the arithmetic abilities was evidenced.

Thus we see that the theory of facility with the fundamental operations may be made to operate in ninth grade mathematics.

SUMMARY.

1. The two examples cited here suggest how the existing gap between theory and practice in ninth grade mathematics may be significantly narrowed by the teacher willing to make the effort.

2. We cannot assume that text books bridge the gap between theory and practice for us.

3. We cannot assume that the previous teachers of our pupils have been successful in applying any of the theories or aims of education.

SOVIET HEALTH PROBLEM.

The government ban on vice in Soviet Russia has turned the age-old problem of disease into new channels. In a book on the venereal disease situation in Russia recently published in Paris, Dr. L. Fridland, a worker in the public hospitals of Moscow, indirectly shifts the blame for the Soviet's mounting disease rate among married couples on the easy divorce conditions prevalent since the Revolution.

In 1917 only two per cent. of the cases of venereal disease seen in Moscow hospitals occurred among married people. In 1924 this rate had risen to ten per cent., Dr. Fridland declares. Out of 100 diseased individuals, only seven infected members of their own families before the war in all Russia, he stated, while in 1918 the figure mounted to 33, and in 1924 had risen to the appalling proportion of 69.

Incomplete cures and the casual marriages that have ensued since divorce laws have become less stringent are believed to be important factors in the situation, which the government is endeavoring to combat by the establishment of "prophylactorium" stations for the disinfection of people at the earliest possible stages of the disease.—*Science News-Letter.*

THE BULLETIN BOARD AS A TEACHING AID.

By G. P. Cahoon,

University High School, Oakland, Calif.

The problem of properly utilizing the wealth of science material which appears every week in current periodicals, is one with which every class room teacher of science is concerned. Not only do such periodicals as the *Science News Letter, Scientific American, Popular Science Monthly, Popular Mechanics, Science and Invention,* etc., contain valuable and interesting articles for high school pupils, but those of a more general and "popular" sort, as the *American, Saturday Evening Post, World's Work,* the *Literary Digest,* etc., are gradually giving a more prominent place to articles dealing with the applications, influences and men of science.

Many of these science articles in both the popular science and the "non-science" type of magazine (if they may be so grouped) are written by prominent writers and scientists and in a very interesting way. Frequently they give new and recent applications of principles and devices, new developments and discoveries, interesting stories of the lives of great scientists and inventors, or episodes in the history and development of important discoveries and applications, that are beyond the various limitations of a text book. They are often more valuable because of the greater detail, the human interest, and the evident "use" which is necessarily lacking in the usual text.

Too often if this material is used at all, it is placed on the bulletin board as a sort of exhibition, rather than used as a means of pupil activity or as a part of the regular class work. Text books, supplementary reference books and material, and laboratory apparatus, for instance, are not simply exhibited on convenient shelves for the pupils to "look over" as interest and time permit. Material posted on the bulletin board needs also to be used as pupil activity and made a part of the class room work—planned, assigned, assimilated and tested like that of any other teaching aid.

A suggestion for the use of the bulletin board. The following is an account of the way in which some of this magazine material was used by means of the bulletin board as part of the class work in the course in physics. It will be evident that it may be equally well used in other science courses, as well as in many other types of classes. It is presented not as an example of a

perfect "technique," but merely as a suggestion which it is hoped may be of value to other teachers.

Checking and clipping articles. It has been our experience that most files of popular and scientific magazines in high school have not been used a great deal as reference material, considering especially the large amount of usable material which a year's file possesses. So after certain magazines have become about a month old (some are kept intact, and not cut up) the articles desired, relating to various phases of physics, are marked and later clipped. In order to save the time of going through a whole group of magazines at once, when the magazine first arrives and is looked over, the articles to be used are immediately marked by "dog-earing" the pages and checking the particular article or picture with a light pencil mark. These may then be cut out later by students or "home" help. In order to get enough clippings to make a start, large numbers of back issues of magazines from one to three years old were looked over, and checked and clipped in this manner. If none of these are at hand, they may usually be obtained for five cents per copy or less, from Red Cross and second hand book stores.

Filing clippings. The clippings are then filed, in folders or boxes, first according to the main divisions of physics under which they fall—as mechanics, heat, sound, light, magnetism and electricity, and radiations. Two other main divisions were also provided for: biographies and pictures of physicists and inventors, and miscellaneous. As the material accumulates, other divisions or subdivisions will need to be provided, such as dividing mechanics up into air phenomena, liquid pressure, force and matter, machines, etc. The clippings in each main division are filed in folders under subtopics which conform as much as possible to the topics to be treated in the study of the main division. For instance those in heat have folders labeled: *thermometry and expansion; specific heat; condensation, evaporation, distillation; refrigeration and artificial cooling; transference, heating, ventilation, hygrometry and weather; steam engines and turbines; automobiles, gas engines.*

After the system is once started and properly organized, this phase of clipping and filing does not take nearly as much time as might be expected, since only the articles from the new magazines have to be so treated—and one can mark the articles the first time he looks over the new issue of the periodical and cut them, or have them cut later at odd times. The filing of the

clipped articles is a matter of a very few minutes, once the folders have been arranged.

The filing boxes. A separate box or pamphlet case is provided for each of the half dozen or more main divisions. This is about the size of the ordinary filing or transfer case. It may be easily and quickly constructed by using two wooden end pieces, and chip board for the back and sides. The chip board should be all in one piece, but cut part way through its thickness where it is to be bent around the end pieces. The pamphlet cases constructed and used at University High School are 13 inches high, 10¼ inches deep, and 3¾ inches wide (outside dimensions). A piece of chip board 24 x 13 inches is placed lengthwise, and 10⅛ inches measured off from both ends. At these two points a knife line is made across the chip board, cutting about ⅓ through, so that the chip board will not break when bent. A strip of redwood (any other soft wood could be used) 3½ x 10⅛ x ½ inch is then brought into place and nailed on the two sides and one end, flush with one edge of the chip board. A similar redwood strip is fastened into place for the other end. The side or face of the chip board which was cut is placed outside after bending, and over the half open seam which thus forms the edges of the completed box, a length of 2-inch "Quick set tape" (a gummed paper) is bound.

The folders. The folders may be typical manilla filing folders. Or they may be easily made from manilla tag or heavy paper—even heavy wrapping paper is quite satisfactory. A strip of paper 19¼ inches long and 11¾ inches wide is folded 10 inches from one end, so that one side of the folder is about ¾ inches longer than the other. Half of this strip, which extends beyond the rest of the folder, may be cut out, cutting the whole ¾ inch width, but only half the length of the folder; the other half will then serve as a filing tab, where the designation of the contents may be written. Alternate sides of the folders are cut, so that the contents may be determined easily without thumbing every folder that is filed in the box.

Background for mounting. The clippings relating to a certain phase of a main topic (e. g. *expansion* in the topic of heat) are then mounted on some sort of background and an appropriate title or catch phrase lettered on. The material used for background can be suited of course to individual taste and the materials at hand. A very suitable mounting has been the kind of

brown paper used by librarians to cover books and pamphlets. Manilla tag is satisfactory, though it is lighter in color.

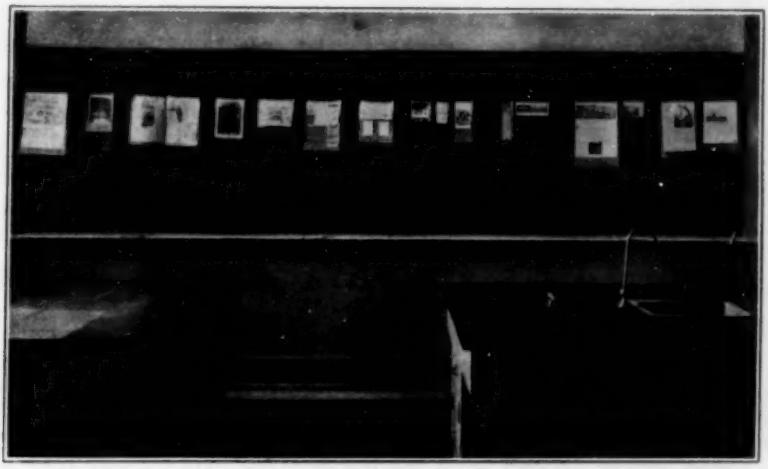
This background should extend outside the clipping, of course, to furnish about a half inch border, with possibly an inch and a half space at the bottom for the title, if one is to be included. A rather heavy black or colored line is placed about a quarter of an inch in from the outside edge of this background border, by means of a ruling pen and india or show card ink. This margin of course could be omitted, but it sets off the whole in such a way that the time taken is well worth the result.

Attaching clippings to background. Rather than paste the clippings onto the background sheet with library paste or glue, they are attached by means of two small strips of gummed paper, bent like a hinge. These strips are about one-half inch wide by an inch and a quarter long, and can be cut from the regular gummed binding tape, such as the *Quick set* or that used by librarians. Regular stamp hinges as used by stamp collectors may also be used, and may be purchased for a few cents per thousand. Four hinges, one for each corner, are sometimes more satisfactory, especially when drafts are present. This method of attaching allows the clipping to be pulled off if desired and attached or filed elsewhere, without damage to either the clipping or the background. It is also much quicker and less mussy than pasting.

The titles. The titles should be lettered on with a fairly wide lettering pen if possible, though typewritten strips pasted or hinged on are also satisfactory. The latter is illustrated in the mounted clipping on the extreme left in the photograph of the figure. The titles should be of a nature to arouse interest, bring out the purpose of the article or its relation to the topic being studied, or point out a striking statement. Sometimes the titles on the clippings themselves are sufficient. Some of the titles used on the clippings in the accompanying photograph (but which are probably too small to read as here reproduced) are: *Some delicate changes recorded by means of light. Some animals can see ultra violet rays! How will these results affect the wave theory? If we could harness the energy of atoms!*

At the beginning of the study of a certain phase of a unit, all the mounted and "titled" clippings on this phase are neatly arranged on the bulletin board. There should be a general title covering this phase for the whole bulletin board, suggesting the theme which the articles are concerned with. This is illustrated

in the photograph. To be most effective, since most of the articles posted are printed in type used for reading at close range, the articles should be arranged on the board with the printed clippings as nearly on the level of the eyes as possible. Charts, pictures, diagrams, etc., may be placed somewhat higher if it is necessary to meet space requirements. The mounted clippings should not be jammed too closely together, since it not only spoils the appearance, but does not allow a group to read at the same time. A fairly good arrangement in this respect is shown in the figure.



A "wire" bulletin board. A very good means of presenting the mounted clippings so that they are at a proper height and not too close together is to hang them on a wire stretched across the back or sides of a room. The wire should be about six feet from the floor, and stretched as tightly as possible. About number 16 iron wire is best. (Copper wire, of course, will stretch.) Ordinary paper clips—the long narrow kind—are strung onto the wire either before or after it is stretched up. The mounted clippings may then be attached to the clips and spaced as desired. If the wire is stretched across a blackboard, desired lettering may be added with white or colored chalk. A bulletin board of this type is illustrated in the figure.

Portable bulletin boards. Portable bulletin boards were made from two large discarded picture frames. Wall board was used for the backing and covered with green burlap. Chip board may also be used, though thumb tacks are not so easily pulled

out. A somewhat smaller board, similarly constructed, but without the frame, and having a braced base so that it is self supporting, is used for showing particular clippings, diagrams, charts or pictures, to the class as a whole, during a discussion, demonstration or report.

Time between changes. Since the bulletin board material on each phase of the unit is presented at the beginning of the study of that particular phase, it can and should remain up until the study of that portion has been completed. This will vary from one to four or five weeks, depending upon the topic and the time available for the unit. Usually two or three weeks makes a good length of time between "shifts." During this time frequent references are made to particular articles, and pupils are encouraged and urged to make use of the bulletin board. However, unless a definite time and opportunity is given during which the pupils are expected to use the bulletin board as they would any other class room material, very few will make any extensive use of it. Usually they cannot, even if they desire, since they have no time to spend between classes, and have other required activities to be attended to while in the regular class or laboratory period.

Using the bulletin board. Near or at the end of the period during which the phase of the unit covered by the bulletin board is being studied, a definite time is given when the members of the class read each article on the board. The length of this time will of course depend upon the material but will usually take at least a double forty minute period. The procedure is a type of directed study. Questions on the articles of the bulletin board are hectographed so that each pupil has a copy. The questions may be written upon the blackboard, though it is not as satisfactory. With these questions as a guide the pupils read the articles and write down the answers, which are turned in at the end of the period. It is a good plan to have the number of mounted clippings equal to at least the number of pupils in the class. The clippings may be numbered and the corresponding questions indicated on the question sheets, so that no time is wasted in the necessary skipping around.

Type of questions. The questions used in this method should not be of such a nature that the answers require or encourage the copying of a portion of an article. The specific answer, completion, true-false, or multiple choice type of questions give not only a satisfactory means for aiding the pupil in reading and studying

the articles, but also for quickly and objectively determining how well he has been able to get the important facts or ideas or appreciations. The pupils themselves can correct objectively made tests of this type in class. Time enough is allowed after correcting for a discussion of the articles in their relation to the principles and topics being studied in the unit. If it seems desirable, a test covering this bulletin board material may be given separately after the directed study and discussion period, when the pupils do not have access to the material. Or questions involving the articles and points brought out in the discussion may be included in a check-up quiz at the end of the particular unit or phase.

Periodicals and sources of material. Of the periodicals which have been found to afford good material for bulletin board purposes, the following have been particularly valuable for physics: *Science News Letter; Scientific American; Popular Science Monthly; Science and Invention; Popular Mechanics; Radio News; Literary Digest; Saturday Evening Post; Country Gentleman; American.*

With the new printed form of the *Science News Letter*, and its arrangement so that each article is headed by the name of the particular science with which it is concerned, this weekly periodical has become one of the best sources of bulletin board and supplementary material. It is arranged especially for clipping, so that no important article on the reverse side is cut into or covered up when an article is cut and posted.

Besides the newspapers, especially Sunday supplements and "rotogravure" sections, numerous pamphlets and literature even of an advertising nature can also often be used to advantage. These frequently furnish good pictures and diagrams of new devices and applications at least.

Outcomes. Such use of the bulletin board provides an interesting and valuable pupil activity which, with the lively discussion that it invariably evokes, furnishes a training not only in acquiring some extra bit of knowledge (probably in itself quickly forgotten) but also in an appreciation of what physics "is all about," where it functions outside of the text book, and of the part which it plays in the work and comfort of mankind, and the progress of the world. If properly guided, it should also aid pupils in a truer evaluation of the material relating to science as found in current periodicals.

AN EXPERIMENT WITH A SCIENCE CLASS.

By J. L. Cooprider,

Central High School, Evansville, Ind.

In the autumn of 1926 our science department woke up to the fact that a large number of our students in general science were failing. In order to relieve this situation this experiment was attempted.

A study was first made of the personnel of the students then enrolled in the general science classes. It was soon discovered that the large percentage of the failures were among the boys. Since our classes were divided into boy and girl sections this study was then confined to the boy group. Of the 108 boys enrolled in the 9B science, 11 or 10% failed in this science and in addition 11% had either dropped the course or withdrew from the school. The next step was to single out this 10% who failed and other students who were near failure and were probably passed "by the grace of the gods."

After due investigation it was decided that 30 of the 108 boys were eligible for a special class in their 9A general science, and forthwith these chaps were admitted to a special class regardless of whether or not they had made their 9B credit.

A summary of the work done by these 30 boys in their 9B semester is interesting. It was possible for these 30 boys to make 120 credits in all subjects including science, but their records show that 30 or 25% of their credits were actually lost by failure. It was also discovered that these lads had dropped a total of eight subjects, or 6% of their possible credits were lost through dropping subjects. Now if we combine these two tabulations we see that 31% of their possible 120 credits in all subjects were lost through either failure or dropping.

Further reasons for segregating these 30 boys might be in order. Their I. Q. was very low. In 23% of the cases it was below 80.0 and in 33% of the cases it was between 80.0 and 90.0. It is a statistical fact that pupils with an I. Q. of below 78 cannot read. The records of these boys also showed that they were "pests in the office." They were being marked tardy, or were absent from school, or they were being complained about by one or several teachers, they were being detained after school, etc.

What are some of the statistical results of the experiment? 100 boys were enrolled in 9A science. Of this number 11% either withdrew from school or dropped the science. Of those

who remained throughout the semester, there were no failures. Thus we reduced our failure from 10% one semester to 0% the following semester.

But the results of the special class in science were the most interesting. Only 24 of the 30 boys remained in the class the entire semester, one having dropped the course, one moved out of the city and the others went to work. It was possible for these 24 boys to make 96 credits in all subjects, they actually made 86, having lost about 9% due to failure and about 1% due to dropping the course. From the administrative point of view this is extremely important. Think of reducing the failure and dropping list from 31% to 10% loss of credit!

The statistical study is interesting to some but the greater results of the experiment are not expressed in figures. Who were these boys at the beginning of this special course in science? It would have to be admitted they were probably classified by the administration, by teachers and others, as the "scum of the earth." But our science department woke up to the fact that they were some species of *homo sapiens*, and that if they lived long enough, and they probably would, they would be citizens in a few years. Then it was up to us to do something that would make them better citizens and I believe that is what we accomplished.

It was stated above that these boys were "segregated" in a "special" class. This should not be misunderstood. At no time before, during or after this, was a single boy of the group made conscious of the fact that he was thus classified. The words special and segregated hung over a class is itself enough to make them afraid of torture. The reason that many such classes fail is probably due to the fact that the teacher or someone else cannot keep a secret. Such a teacher usually gets the idea that his or her room is being made the "dumping ground" of the school and before they are aware of it they are appealing to some fellow teacher for sympathy.

Interest and morale was high at all times in this special class. This may have been due to a number of things. There were fewer individual differences in the mentality of the personnel of the group. This gave everyone in the group a greater opportunity to state what he desired without fear of criticism from a lad with "keener" mind. Questions upon the subject which were asked by the boys were given the greatest of attention. This made each one feel that what he had to ask, if it were in

order, was not only a contribution to his own knowledge but also to members of the group. When a student failed to give the correct answer he was not ridiculed but before he sat he was given the correct answer with reasons. Assignments in this class were given so that the class had a reason for studying. Goals of perfection were set up and when a lad did not reach that goal he had a reason or soon found one.

We teachers often fail to remember the old proverb which stated that "no one was intended to be a failure." We often get "stuck" on our position or something and think that to be successful we must be "hard boiled" and show our authority in any way possible. When any boy fails there must be a reason, and that reason is not always that which is uppermost in the mind of the teacher. It was noted above that four boys of the special class withdrew to go to work, and it was noted in these boys' records that only two had made one F and that was in English in each case, and, further the I. Q. in both of these cases was below 70.0. Now, was the reason these chaps withdrew, especially the latter two, that they wished to go to work, was it because they could not read, was it because they became discouraged in English due to failure, or was it some one of countless other reasons?

The desire to make good is probably uppermost in the minds of everyone from the rag-picker to the President of these United States. The boys of this special class will probably never be presidents not even of a hod-carriers union, but they will be citizens and they have a right to make a living, they have a right to make good, and they have a right to the idea that they are getting somewhere in the world. The boys is this special class realized that they were getting somewhere in this science class, hence the desire to make good in their other subjects as well. What can we teachers better do than to train that inner urge for success which is always present? What can be greater than to produce better citizens as a result of having lived whole-heartedly with success in our science class or other class? What greater harm can we do than to make "riff-raff" of certain of our students whom we do not like or who do not apparently make good with us? If a student is not making good, why not attempt to find out the reason? Then if we should find out why not try to be professional about it? The medical man does not tell all he knows as a result of a diagnosis; if he did we should all become M. D.'s and he would be without a profession.

What was accomplished in this class, in the opinion of the writer, can be accomplished in any class. In fact our department has continued this experiment with even greater results than the first experiment. Our department boasts of having a 100% promotion card in science classes for the last semester. This is to say nothing of the many happy boys as well as the teachers, all of whom are glad they are living. Where classification is not possible as in this department, there is no reason why some of the ideas set forth in this paper cannot or should not be used to accomplish similar results.

A METHOD FOR USING THE HISTORY OF CHEMISTRY AS A TEACHING AID.

By I. W. Wade,

New York University, New York City.

When the author was first introduced to the unknown treasure of algebra, the subject was handed down from the pedagogical heights as a "gift from the Gods." There was no hint that men had ever dreamed of it, that characters had ever been moulded by it, or that blood had been shed for its preservation. Personalities, in algebra, were as unknown as the quantity x. Algebra was a stone to be discovered and examined, and although we might have scratched its surface we had no story of its evolution. Later when the author learned of the burning of the most famous library and museum of antiquity, that of Alexandria, by the Arabs, he could not but wonder how algebra had escaped the flames.

When the time came for the author to introduce his first class to the fascination of chemistry, he decided that the subject should be revealed through the lives of the men who served it. Yet such a plan had to be subordinated to the real purpose of the course, it had to be limited in the time it consumed and yet enable the students to realize that chemistry had evolved by the contributions of countless men laboring over the mysteries of matter. After a year of experimentation, of seeing students delve into the magic of Stillman's *The Story of Early Chemistry*, of watching them trace Priestley's journey to America, and of hearing one student convincing another that Sir Wm. Henry Bragg really had something to brag about, the following method of using the history of chemistry was adopted.

Development of the Method.

The method outlined below was designed to be used in high school or college classes of general or inorganic chemistry. At the beginning of the semester each student was assigned the name of an outstanding chemist. The students were held responsible, at any time during the year, for the following information about these men:

I. Life. Under this topic any interesting material concerning the date and place of birth, nationality, early childhood, first interest in science, association with scientific men, etc., was included. Likewise, any outstanding events of non-scientific nature, honors, year and place of death were assembled and reported.

II. Education. The students were asked to discover if possible what reaction the parents of the chemist had toward his desire to study chemistry, or more specifically, to devote his life to it. Items of training for vocations not entered were gathered and attention was directed to the pre-college, college or university training of the man. Light was often thrown upon the career of a man by the great scientific characters under whom he first received instruction in chemistry. In Germany, especially, the result of the influence of great teachers upon students who subsequently became teachers was most significant in the development of chemistry.

III. Work in chemistry. This topic was the key to the success of the method and its full and careful development was assured by suggestions or comments by the teacher. Emphasis was placed upon the work done to which reference was made in the text used. If the work of the man extended beyond the field under discussion only short reference was made to it. Again, this topic determined the time at which the report was due, usually on the day when the class discussion centered about or was dependent upon the work of the man.

IV. Influence on (a) contemporaries, (b) development of chemistry. No extended investigation of influence was demanded, but whenever possible reference was made to the influence of the subject upon his students and his associates. Any real development of the influence of the man and his work on the progress of chemistry came only through reading and was gradually unfolded with the course of study in the class-room and laboratory.

These four topics were covered by a brief oral report in the class-room and by a paper of not more than 1,500 words due at

the end of the school year. Pictures, photographs and original papers and books were collected and a complete reference list was posted for use by the students. It was found in a number of cases that students went so far as to make charts, models and graphs showing some item of work or an incident in the life of the subject. Among the exhibits were pictures of original apparatus used by Priestley, charts of the atomic symbols proposed by the alchemist William Salmon, by Bergmann, Kekule, Dalton and Berzelius; models of the periodic system and of atomic and crystal structures.

The chemists selected were: Boyle, Priestley, Scheele, Cavendish, Lavoisier, Faraday, Wöhler, Meyer, V., Mendeleeff, Avogadro, Dalton, Davy, Berzelius, Gay-Lussac, Kekule, Pasteur, Madame Curie, Arrhenius, Ramsay, Liebig, Bunsen, J. J. Thomson, Rutherford, Moseley, Wm. H. Bragg, Graham, Richards, Hare, Remsen, Langmuir. The selections were made upon the availability of the work of the man upon the development of the course and not upon the ability of the worker. Teachers will find opportunity to adjust the names and their sequence to coordinate the work with the class discussions. This list of thirty could easily be extended to sixty without exhausting the number of distinguished men in chemistry, past or present, American or foreign.

Value and Significance of the Method.

The growing popularity of biography in this country is directing the attention of young people to the significant value of knowing the great personalities and characters of the past. The best introduction to an abstract science is through the study of the lives of those whose work it is, and the cultivation of a human interest in chemistry is justified if it makes the subject more interesting and therefore more easily taught. The cultural value of this use of the history of chemistry has been neglected, while the mechanism of its method has been little explained. Chemistry is a part of those who work with it and their association leaves it enriched by personal as well as abstract truths. Take out of chemistry the method of Lavoisier, the visions of Dalton, the dreams of Kekule, the curiosity of Langmuir and with each will be removed some stone of the foundations upon which chemistry rests or some tower of its amazing structure.

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THE VALUE OF THE HOTZ ALGEBRA SCALES IN SECTIONING COLLEGE CLASSES IN FRESHMAN MATHEMATICS.

BY DR. HAZEL E. SCHOONMAKER,
Ithaca, N. Y.

THE ORIGIN OF THIS STUDY.

In 1922-23 the author of this study was teaching in a college for women where mathematics was required of freshmen. In the first semester this work consisted of algebra and was given in two courses known as "Sub math." and "Math. 1." The "Sub math." course was intended for those who had an entrance condition, that is, for those offering only one unit of algebra for admission instead of the unit and a half required.

After a year of that plan the teacher was convinced that the basis of differentiation was unsound, that the quality of the work presented for admission and the length of time which had elapsed since the last instruction in the subject affected the amount of algebra of which the student was master, far more than the number of units presented for entrance. Moreover, a careful study of the mathematics courses in other colleges of the state showed that "Sub math." courses were no longer given.

In the school where this study was made, the required freshman mathematics consisted of a semester of algebra followed by a semester of trigonometry. This work was given in five sections of from fifteen to twenty pupils each. For the trigonometry a

girl was assigned at random. The five sections of algebra were composed of four sections of Math. 1 filled at random, and one of "Sub math."

Part of the problem was to eliminate the "Sub math." course. It was felt that a method of sectioning the Math. 1 would solve this difficulty. Then the question arose as to what to use as the basis of sectioning, a general survey test, or a standardized test. The ordinary arts faculty is skeptical of many modern educational theories, particularly those involving mental measurements. The situation in this school seemed to afford an excellent opportunity to put some of those theories to a test. In 1923-24 an experiment was tried against much opposition and many attempts to discourage. Instead of having five sections of algebra for one semester, followed by five of trigonometry, it was decided to give four of trigonometry and one of algebra followed by four of algebra and one of trigonometry. This gave flexibility to the curriculum. To fit in with the general schedule of classes and to make transfers possible, these four sections came two at the same time in the morning and two in the afternoon.

At the first appointment in the morning classes the girls were given an examination made out by the teacher. The test covered the four fundamental operations, fractions, simple equations, and a very easy quadratic equation. The marks on a scale of 100 ranged from 0 to 98. There were forty girls taking this test and they were divided equally into two sections according to the results. In the "good" section these marks ranged from 51 up.

The same procedure was used with the afternoon classes, but here the division mark was 67. A difference in I Q would hardly account for this since the median I Q for the morning group was 104.4 and for the afternoon group, 108.7. As two different tests were used, they probably were not of equal difficulty.

In these four sections of trigonometry the same texts were used, the same topics covered, the same final examination given, but the number of problems assigned daily varied.

At the end of the semester it was found that more ground had been covered than under the old system and the groups were more homogeneous as judged by the marks. Graphs showing the distribution of these marks are omitted, but Table 1 gives the medians and standard deviations for the marks and I Q's. In this sectioning no use was made of I Q.

TABLE I.

1923-24 Sections	Md. mark	σ for marks	I Q	σ for I Q	No. of cases
good a. m.	78.1	7.8	109.5	7.6	17
poor a. m.	71.0	9.6	103.5	7.8	17
good p. m.	86.2	12.0	108.2	5.3	15
poor p. m.	63.5	12.1	110.6	9.6	15
1924-25.					
good a. m.	83.2	10.4	112.8	7.4	17
poor a. m.	57.5	9.3	102.5	8.7	16
good p. m.	85.5	13.1	116.6	7.5	14
poor p. m.	60.0	8.8	111.6	8.5	16

Although the method was rather crude, the results were so encouraging that it was decided to try the experiment another year, and this time, in 1924-25, to use as a basis of selection one of the standardized tests, the Hotz First Year Algebra Scales being finally chosen.

The Hotz Scales described in the Teacher's Manual for First Year Algebra Scales, will be referred to in this study as follows: Addition and Subtraction Scale, as Scale 1; Multiplication and Division Scale, as Scale 2; Equation and Formula Scale, as Scale 3; Problem Scale, as Scale 4. The Graph Scale was omitted.

A comparison of the standard medians for these scales with our obtained medians is given in the following table.

HOTZ MEDIANS.

Name of Scale	Standard 3 mos.	6 mos.	9 mos.	Obtained in this study
Scale 1	5.0	6.8	7.9	6.6
Scale 2	5.3	6.3	7.9	5.3
Scale 3	4.9	7.1	7.8	7.1
Scale 4	4.3	4.9	5.6	5.1

In this study the Series A tests were given to 99 girls before they were assigned to any mathematics sections. The number of cases studied was reduced to 75 because in many instances complete data were lacking.

RESULTS WITH THE TESTS.

Clifford Woody in "School and Society" for Sept. 9, 1922, has described a study made with seniors in a Michigan high school. He compares the scores made by seniors on the Holtz Scales with the scores made by high school students taking algebra. He found that seniors retained a relatively large amount of knowledge of the more formal aspects of algebra, but a comparatively small amount of the more complex problem aspects of the subject. Our results agree with his.

The correlations between our scores on the various Hotz Scales are all found to be valid.

CORRELATION TABLE.

	Hotz 1	Hotz 2	Hotz 3	Hotz 4	I Q	Alg.	Trig.
Hotz 1	....	.57	.50	.60	.48	.63	.43
Hotz 2	.57	....	.50	.33	.44	.42	.41
Hotz 3	.50	.50	....	.56	.30	.45	.39
Hotz 4	.60	.33	.56	....	.40	.54	.57
I Q	.48	.44	.30	.40	....	.47	.40
Alg.	.63	.42	.45	.54	.47	....	.80
Trig.	.43	.41	.39	.57	.40	.80	....
Av.	.52	.44	.45	.50	.41	.55	.50

The Otis Self-Administering Test, Form B, was used to determine the intelligence of the 75 cases studied. The scores were translated into I Q's by the Interpretative Chart provided with the test, the median I Q falling at 109.77. It is generally asserted that a student with an I Q of less than 110 probably cannot successfully complete the college course, and the scholastic record of these 75 cases seems to bear out this conclusion.

The correlations of the Hotz Scales give nothing new. The range of values from .30 to .48 was expected, for most studies show that intelligence and scholarship have low correlations. It is natural for the Addition Scale to have the highest correlation since it involves the simpler fundamental operations and the types of exercises for which practice effects would be most noticeable.

Letter grades were given the class for a term's work in mathematics. Then these were translated into numerical marks. The median mark for the 75 cases studied was found to be 70.7 for trigonometry, and 72 for algebra. These marks for trigonometry the first term and for algebra the second had a correlation with each other of .80. Although it is not perfect, such a high correlation seems to justify the use of a standardized test in algebra to section trigonometry classes.

The correlation of the I Q's with trigonometry and algebra yield results in agreement with those of other investigators such as Whipple and Buckingham. In comparing class marks in algebra with scores on the Hotz Scales, this study seems to indicate that the Addition and Subtraction Scale is the more valuable one, at least for the content of the algebra course as it was given.

Undoubtedly some misplacements occurred. These were corrected the second semester by transferring to a different section, the work of the first semester being largely the determining factor. The use of I Q in conjunction with scores on the survey or standardized tests would have prevented many such misplacements.

Conclusions.

From our study we feel justified in concluding that

1. The "Sub math." course is superfluous and the situation from which it arose is adequately provided for by a method of sectioning.

2. Our results confirm those of previous studies to the effect that correlations of intelligence and school marks between .40 and .60 are to be expected and are significant.

3. A significant difference in the I Q's of class groups is reflected in the class marks.

4. Examinations covering a unit of algebra, given to students offering a unit and a half for admission to college, but completed two or three years prior to entrance, yield medians approximately equivalent to the standard six months' medians for high school algebra.

5. The Hotz Scales proved no better for sectioning than the general survey test, but they did offer a wealth of information useful for diagnostic purposes. They can be used for sectioning classes in trigonometry as well as algebra.

6. An arts faculty should make more use of educational theories, particularly along the lines of mental measurements.

PROBLEM DEPARTMENT.

Conducted by C. N. Mills,
University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

SOLUTIONS.

1019. *Proposed by E. de la Garza, Brownsville, Texas.*

Suggested by 1005. From any point on the circumcircle of a given triangle, lines are drawn making equal angles with the sides of the triangle. Prove the points of intersection of these lines with the sides are collinear.

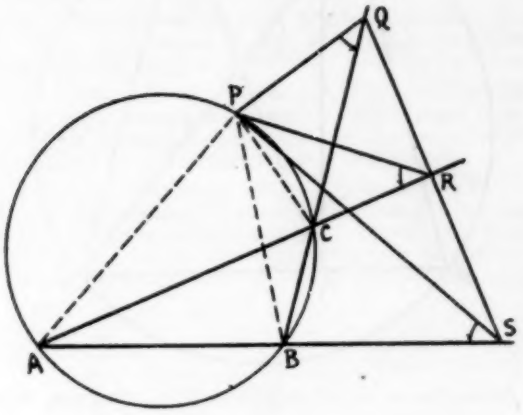
I. *Solved by Bessie Green-Andrews, Wichita, Kansas.*

Given triangle ABC and the point P on the circumcircle with PD, PF, and PE, making equal angles with the sides. Draw the perpendiculars, PM, PO, and PN, to the sides. Since the obliques make equal angles with the sides, they also make equal angles with the perpendiculars to the sides. Thus the pencil formed by the obliques is congruent to the pencil formed by the perpendiculars. Since the triangles MPD, OPF, and NPE are similar, each oblique is k times the corresponding perpendicular. Since points M, N, and O are known to fall on a straight line, the Simpson line

of the triangle, then D, F, and E will fall on a straight line parallel to the Simpson line, if the pencil of obliques is rotated through and angle equal to MPD.

II. *Solved by George Sergent, Tampico, Mexico.*

Let PQ, PR, PS be the oblique lines drawn from any point of the circumcircle of triangle ABC to the sides a, b, c, respectively, so that $\angle PQB = \angle PRC = \angle PSA$. By the reciprocal of *Theorem of Menelaus*,



the proposition is true if

$$\frac{SA \cdot QB \cdot RC}{RA \cdot SB \cdot QC} = 1.$$

Draw PA, PB, PC. The triangles PAS and PCQ are similar, since $\angle S = \angle Q$, and $\angle PAS = \angle PCQ$, as measured by $\frac{1}{2}$ arc PCB. Hence,

$$SA : QC = PA : PC. \quad (1)$$

The triangles PAR and PBQ are similar, for $\angle R = \angle Q$, and $\angle PAR = \angle PBQ$, as measured by $\frac{1}{2}$ arc PC. Hence,

$$QB : RA = PB : PA. \quad (2)$$

The triangles PCR and PBS are similar, for $\angle R = \angle S$, and $\angle PCR = \angle PBS$, as measured by $\frac{1}{2}$ arc ABCP. Hence,

$$RC : SB = PC : PB. \quad (3)$$

Multiplying (1), (2), (3), member by member, we get

$$\frac{SA \cdot QB \cdot RC}{RA \cdot SB \cdot QC} = \frac{PA \cdot PB \cdot PC}{PA \cdot PB \cdot PC} = 1.$$

III. *Solved by F. A. Cadwell, St. Paul, Minn.*

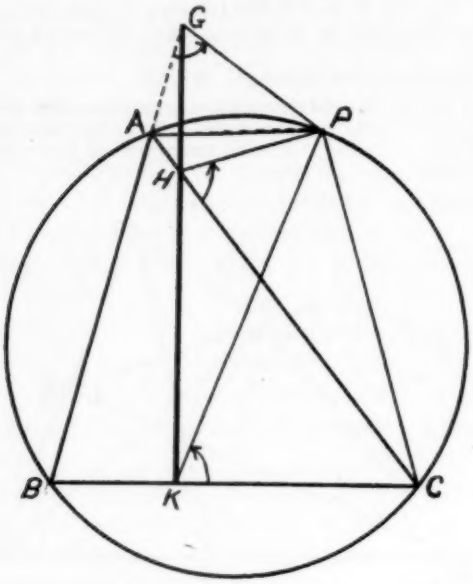
Let ABC be the triangle and P a point on its circumcircle. Let K, G, and H be the points on BC, AB, and AC, respectively, such that $\angle PKC = \angle PGB = \angle PHC$. To prove that K, G, and H are collinear.

Draw KH, HG, PA, and PC. Since $\angle PHC = \angle PKC$, a circle may be circumscribed about the quadrilateral PHKC. Then $\angle PCB + \angle PHK = 2$ rt. $\angle$s. Since ABCP is an inscribed quadrilateral, $\angle GAP = \angle PCB$. Hence, $\angle GAP + \angle PHK = 2$ rt. $\angle$s. Since $\angle PHC = \angle PGB$, a circle may be circumscribed about the quadrilateral AGPH. Hence $\angle GAP = \angle GHP$, and $\angle GHP + \angle PHK = 2$ rt. $\angle$s. Therefore the points G, H, and K are collinear.

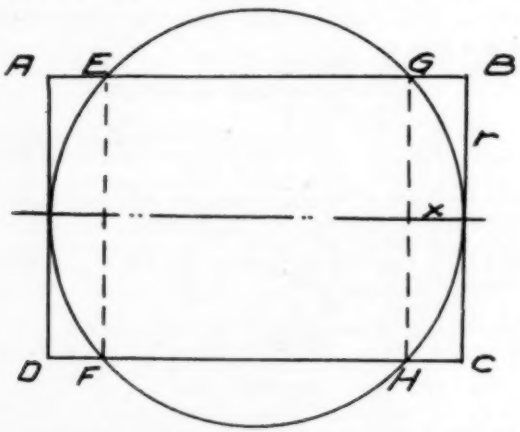
Also solved by *S. M. Turrill, Crane Junior College, Chicago, Ill.*

1020. *Proposed by George Sergent, Tampico, Mexico.*

A cylinder bisects the volume of a sphere of radius unity, and its axis is a diameter of the sphere. Find radius of cylinder.



I. *Solved by R. E. Morris, Lewis and Clark H. S., Spokane, Wash.*



The volume of half the sphere equals the volume of the cylinder EFGH and the two spherical segments on bases EF and GH. Let x be the altitude of the one base segments. Then, since radius of sphere is unity, (R being the radius of the cylinder)

$$(2-2x)R^2\text{pi}+(2/3)\text{pi}\ x^2(3-x) = (2/3)\text{pi}.$$

Also $$R^2 = (2-x)x.$$

Eliminating R, we obtain the cubic

$$x^3-3x^2+3x-.5 = 0.$$

By Horner's method, we find $x = .2063$; hence $R = .6083$.

II. *Solved by Raphael Robinson, Berkeley, Calif.*

Notation refers to Figure for Solution I. Let k be the distance of planes EF and GH from the center of the sphere. Then $R^2 = 1-k^2$. $2k$ = the height of the cylinder, and its volume is $2\text{ pi } k(1-k^2)$.

The volume of the segment of the sphere between the plane through the center and a parallel plane at a distance k from the center is pi$(k-k^3/3)$. Hence the volume of the two base segment determined by the planes EF and GH is equal to 2 pi $(k-k^3/3)$. The volume of that part of the sphere outside the cylinder is (4 pi k^3)/3. Since the radius of the sphere is unity its volume is 4 pi/3. Hence

$$(4 \text{ pi } k^3)/3 = 4 \text{ pi}/3.$$

We find k = the cube root of (1/2); Hence R = square root of $(1-k^2)$ = .6083, the radius of the cylinder.

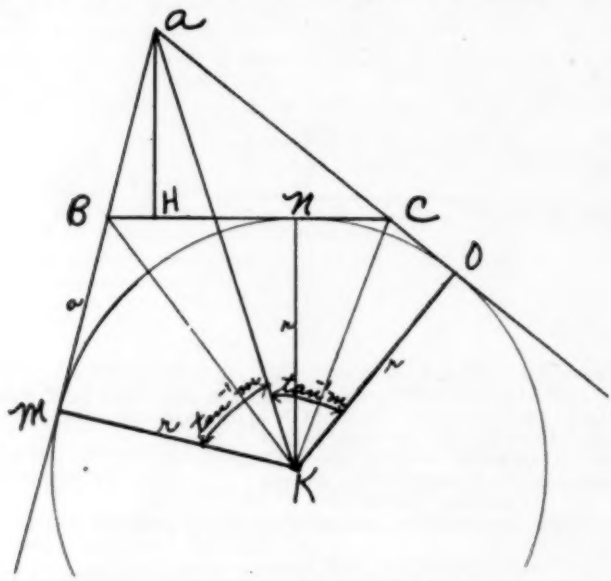
Also solved by *Paul Mount-Campbell, Monte Vista, Colo.; R. A. Bromar, Mishawaka, Ind.; C. J. Leonard, Detroit, Mich.; Raymond Huck, Johnson City, Ill.; E. de la Garza, Brownsville, Texas;* and the *Proposer.*

1021. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

The product of the distances of the vertices of a triangle from the center of an escribed circle is equal to the square of the diameter of the circle considered multiplied by the circumradius of the triangle.

I. *Solved by Bessie Green-Andrews, Wichita, Kansas.*

Let r represent the radius of the escribed circle; a, the length of the tangent MB; and arctan m the angle MKA. These three mutually independent quantities determine the entire figure. Therefore, all other magnitudes may be expressed as functions of r, a, and m.



$\angle$NKC equals arctan m minus $\angle$BKM; hence its tangent is $(rm-a)/(r+am)$, since the tangent of $\angle$BKM is a/r.

$$\text{CO} = \text{CN} = \frac{r^2m-ar}{r+am}.$$

$(\text{BK})^2 = a^2+r^2$, $(\text{AK})^2 = r^2+r^2m^2$, and

$$(\text{CK})^2 = (r^4+a^2m^2r^2+r^4m^2+a^2r^2)/(r+am).$$

Hence, $\text{AK}\times\text{BK}\times\text{CK} = r^2(1+m^2)(a^2+r^2)/(r+am)$. (1)

$$\text{AB} = rm-a, \quad \text{AC} = ar\,(1+m^2)/(r+am),$$
$$\text{BH} = (a^2-r^2)\,(a-mr)/(r^2+a^2),$$
$$\text{AH} = 2ar(rm-a)/(r^2+a^2).$$

Since (ABxAC)/2AH equals the circumradius, then

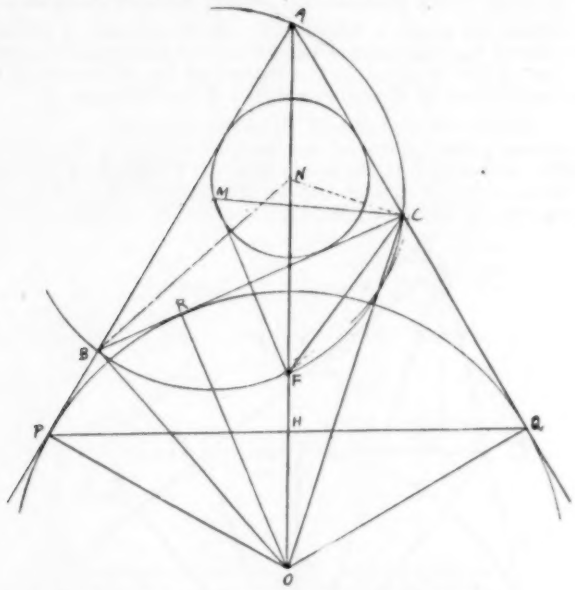
$$\text{circumradius} = (m^2+1)(r^2+a^2)/4(r+am).$$

Hence the square of the diameter of the escribed circle times the circumradius gives the expression (1), which proves the theorem.

Editor. It will be an excellent exercise for readers to deduce the expressions for the line segments mentioned in this proof.

II. *Solved by F. A. Cadwell, St. Paul, Minn.*

Let ABC be the triangle; the circle (center O) escribed to BC touch BC at R, AB produced at P and AC produced at Q; N is the center of the inscribed circle, and M is the center of the circumcircle. Draw OC and OB; OA intersecting the circumcircle at F; OP, OQ, and OR; PQ intersecting OA at H; and MC, MF, BN, CN, CF.



To Prove: $OC \times OB \times OA = (2\,OP)^2 \times MC$, or $4\,MC \times (OP)^2$.

Since $\angle NCO$ and $\angle NBO$ are right angles, a circle may be circumscribed about the quadrilateral NCOB, and ON is its diameter. Also OR (= OP) is the altitude on BC of the triangle BOC. Hence,

$$OC \times OB = ON \times OR = ON \times OP. \qquad (1)$$

Considering the triangle OPA we get

$$OA \times OH = (OP)^2. \qquad (2)$$

Multiplying (1) by (2) we obtain, after dividing by OH,

$$OA \times OB \times OC = (OP)^2 \times \frac{ON \times OP}{OH}. \qquad (3)$$

Therefore if it is shown that (ONxOP)/OH is equal to 4 MC the theorem will be proved.

Since the triangle CMF is similar to triangle PAQ, we have MC/FC = AP/PQ. By a well known proof, FC equals FN equals ½ON, hence 2 MC/ON = AP/PQ. Therefore we get, after multiplying the last expression by 2, 4 MCxPQ = 2 APxON, hence

$$4\,MC = (2APxON)/PQ. \qquad (4)$$

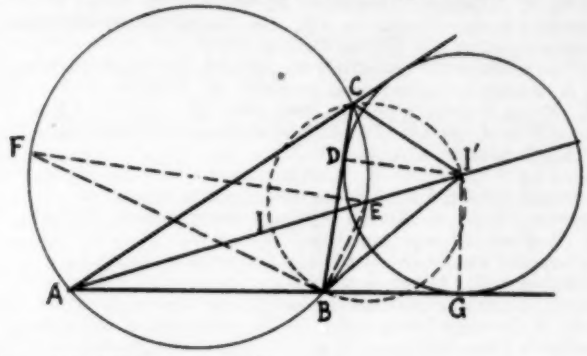
Since triangles APH and OPH are similar, AP/PH = OP/OH, and 2AP/2 PH = OP/OH. But 2 PH equals PQ, hence 2 AP/PQ = OP/OH. Making this substitution in (4) we have

$$4\,MC = (ONxOP)/OH,$$

which completes the proof.

III. *Solved by George Sergent, Tampico, Mexico.*

Let ABC be the triangle, R its circumradius, I the incenter, I′ the excenter relative to A, II′ = d. $\sqrt{}$a the radius of the escribed circle I′, I′D the radius perpendicular to BC, E the point where the circumcircle bisects II′ and the arc BC, EF the diameter of circle O, perpendicular to BC. The circle described on II′ as diameter passes through B and C.



To prove: I′AxI′BxI′C = $4r_a^2R$. (1)

For the triangle I′BC we have I′BxI′C = dr_a (2)

(*Theorem*: The product of two sides of a triangle is equal to the product of the diameter of the circumcircle by the altitude to the third side). Dividing the expression (1) by this expression, we have left to prove

$$I'A = 4r_a R/d = (2r_a R)/(d/2).$$

In circle I′ draw the radius I′G ⊥ to AB; in circle E the radius EB = $d/2$; in circle O, the chord BF. The right triangle AGI′ and FBE are similar, hence I′A:EF = I′G:EB, or

I′A:2R = r_a:$d/2$, whence I′A = $(2r_aR)/(d/2)$. Multiplying this expression by (2) we get the required expression (1).

IV. *Solved by Norman Anning, University of Michigan.*

Editor: Notation refers to figure for Solution III.

$$I'A = r_a csc(A/2),$$
$$I'B = r_a sec(B/2),$$
$$I'C = r_a sec\ (C/2).$$

Therefore the product

$$I'AxI'BxI'C = r_a^2 r_a\ csc(A/2)\ sec\ (B/2)\ sec(C/2).$$

But

$$r_a = 4Rsin(A/2)\ cos(B/2)\ cos(C/2);$$

substituting this value for r_a in the last expression, and carrying out the multiplication, we get

$$I'AxI'BxI'C = 4r_a^2R.$$

Also solved by *Fred A. Lewis, University of Alabama; E. de la Garza, Brownsville, Texas* and the *Proposer.*

1022. *Proposed by E. de la Garza, Brownsville, Texas.*

Given the sides a, b and c of a triangle, determine the amount x that must be subtracted from the length of each side, to make the triangle a right triangle M. Check using $a = 40$, $b = 32$, $c = 31$.

Solved by S. M. Turrill, Crane Junior College, Chicago, Ill.

For consistency let a be the largest side, then

$$(a-x)^2 = (b-x)^2 + (c-x)^2.$$

Rearranging as a quadratic we get

$$x^2+2(a-b-c)x = a^2-b^2-c^2.$$

Solving we get

$$x = (b+c-a) \pm \sqrt{2(a-c)\ (a-b)}.$$

Using the positive sign before the radical and substituting the given values of a, b and c, we find $x = 11$.

Also solved by *George Sergent, Tampico, Mexico; Glenn E. Hewitt, Fort Wayne, Ind.; Raphael Robinson, Berkeley, Calif.* and the *Proposer.*

1023. *Proposed by George Sergent, Tampico, Mexico.*

AB is a chord of a given circle. Determine on the circle a point X, such that $(AX)^2 = ABxXY$, XY being the perpendicular distance from X to AB.

Solved by S. Kullback, Brooklyn, N. Y.

At A erect a perpendicular to AB. On this perpendicular measure from A a distance equal to AB, giving the line AB′.

On AB′ as a diameter construct an arc of a circle intersecting the given circle at X, which is the required point.

Proof. From X draw a perpendicular to AB′, cutting AB at X′. Draw AX. Since X is on the arc of a semicircumference, AXB′ is a right triangle. Hence, $(AX)^2 = AB'xX'A = ABxXY$.

Comment by F. A. Cadwell. Other points which satisfy the conditions may be found by drawing AB′ in the opposite direction.

Also solved by *S. M. Turrill, Crane Junior College, Chicago, Ill.; F. A. Cadwell, St. Paul, Minn.* and the *Proposer.*

1024. *Proposed by E. De la Garza, Brownville, Texas.*

Suggested by 983. Given a sphere and a circular cone resting upon the same plane; the radii of the sphere and of the base of the cone being equal, the height of the cone being equal to the diameter of the sphere. Find at what distance from the summit of the cone must pass a horizontal plane to cut both solids, so that the areas of the sections are aequivlent.

Solved by Paul Mount-Campbell, Monte Vista, Colo.

Let X be the required distance of the apex of the cone from the cutting plane; R the radius of the sphere and also the radius of the base of cone; 2R the height of the cone.

The area of the section in the sphere is

$$\text{pi}[R^2 - (X-R)^2].$$

The area of the section in the cone is $(\text{pi})X^2/4$.

Equating and simplifying these two expressions we get

$$5X^2 - 8XR = 0.$$

Hence $X = 8R/5$ or 0.

Also solved by *R. E. Morris, Lewis and Clark H. S., Spokane, Wash.; Raphael Robinson, Berkeley, Calif.; S. M. Turrill, Crane Junior College, Chicago, Ill.; George Sergent, Tampico, Mexico; Sam Bamberger, Harrisburg, Pa.; Raymond Huck, Johnson City, Ill.;* and the *Proposer.*

PROBLEMS FOR SOLUTION.

1037. *Proposed by George Sergent, Tampico, Mexico.*

Suggested by 1010. A cubical box, side 10 inches internally is half full of water. What is the diameter of a ball, which can be put in and just covered with water?

1038. *Proposed by M. Freed, Los Angeles, Calif.*

Within a given angle A inscribe an equilateral triangle having a given point P as a vertex. P is not on the side of the angle.

1039. *Proposed by Norman Anning, University of Michigan.*

Solve the following equation:

$$\frac{1}{x+1} - \frac{2}{x+2} + \frac{1}{x+3} = 0.$$

1040. *Proposed by the Editor.*

Establish the following relation which is found in *Solution IV* of Problem 1021 in this issue:

$$r_a = 4R \sin(A/2) \cos(B/2) \cos(C/2).$$

1041. *Proposed by George Sergent, Tampico, Mexico.*

The base of a triangle, the median, and the internal bisector from the opposite vertex are given. Show how to compute the other two sides.

1042. *Proposed by E. de la Garza, Brownsville, Texas.*

The sides of a triangle are three consecutive integers, and the largest angle is twice the smallest angle. Find the sides.

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Please send in tests and examination papers.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

QUESTIONS AND PROBLEMS FOR SOLUTION.

525. *Proposed by Sudler Bamberger, 641 Schuylkill St., Harrisburg, Pa.*

A Rewording of Question 513. My problem published and answered in the June issue of SCHOOL SCIENCE AND MATHEMATICS is not my original problem. My original problem was intended to be:

A freely falling body moves through a considerable distance and the variation of g, the acceleration of gravity, must be taken into account. The ordinary formulae for freely falling bodies will be inapplicable. Find corresponding formulae for the body.

526. *Proposed by John C. Packard, Brookline, Mass.*

7 Dana Street, Brookline, Mass.
July 29, 1928.

My dear Franklin T.:

Have you ever seen the enclosed before? The problem was written on the board in a room occupied by the Convention of the Society for Promotion of Engineering Education, held at M. I. T. during the past three weeks, with the caption "Type of Problem for Home Work." I have worked out the answer and find it to be *five* feet.

Cordially yours,
J. C. PACKARD.

Problem. Hanging over a pulley there is a rope with a weight at one end; at the other end hangs a monkey of equal weight. The rope weighs 4 oz. per foot. The combined ages of the monkey and its mother are 4 years and the weight of the monkey is as many pounds as its mother is years old. The mother is twice as old as the monkey was when the mother was half as old as the monkey will be when the monkey is 3 times as old as its mother was when she was 3 times as old as the monkey was. The weight of the rope and weight is half as much again as the difference between the weight of the weight and the weight of the weight plus the weight of the monkey. What is the length of the rope?

[Please check up on Packard. He may be "monkeying" with us.—Ed.]

EXAMINATION PAPER.

AS GIVEN BY THE COLLEGE ENTRANCE EXAMINATION BOARD.

This paper must be returned by the candidate with his answer book. His name should be entered on this line.....

BIOLOGY

FRIDAY, JUNE 22, 1928, 2 P. M. TWO HOURS.

Answer four questions from Group A and four questions from Group B.

GROUP A

1. Indicate the principal excretions and the structures or organs involved in the process of excretion in *(a)* man, *(b)* tree.
2. A fish eats an insect. *(a)* State three functions of the fish which necessarily affect this food before it can be utilized by the cells. *(b)* State two primary uses which make this food essential to the fish.

3. *a)* What is the essential difference between a spore and a seed?
   b) Give an example of plant reproduction which involves neither spores nor seeds.
   c) Name two different plants which reproduce by spores.
   d) Name an animal which may reproduce from spores.
4. *a)* Account for the annual rings in a dicotyledonous stem.
   b) Explain why such rings are lacking in a monocotyledonous stem.
5. Draw the side view of a fish or frog, showing the main external features, and label ten structures.

GROUP B

6. Indicate the source and use of water in a fern or flowering plant.
7. Write briefly on the care of the young as shown by a member of each class of vertebrate animals.
8. *a)* Name four plants, each of which is economically detrimental for a different reason. State the reason in each case.
   b) Name four plant products, each of which is of economic benefit for a different reason. State the reason in each case.
9. *a)* Mention the chief ways by which infections of protozoa or bacteria are incurred.
   b) Give a typical example of each method.
10. Each statement below is true or false. On your paper list the letters *a* to *j* on successive lines. These will refer to the corresponding lettered sentences given below. Opposite each letter write the word *true* or the word *false* according to your judgment.
    a. The honey bee has complete metamorphosis.
    b. An imperfect flower is one which lacks either stamens or pistil.
    c. The larynx leads from the pharynx to the lungs.
    d. Arteries carry only oxygenated blood.
    e. Invertebrate animals are distinguished, in general, by the possession of an internal skeleton.
    f. Most of the water used by a tree is absorbed through the stomata.
    g. The stomata are mostly in the lower epidermis of a leaf.
    h. The hilum assists the hypocotyl in breaking through the seed coat.
    i. The alimentary canal means the excretory system.
    j. Saliva secretes a hormone called ptyalin.

MORE DISCUSSION OF 509

509. *Original problem submitted by Charles Woolley, Ridgewood High School, Ridgewood, New Jersey.*

A boy on a train moving at the rate of 45 miles per hour plays a stringed instrument. A string a meter in length and 1 1-2 mm. in diameter vibrates 380 times per second, the temperature being 77°F. If the string be made 500 mm. in length and 3 mm. in diameter, at the end of 2 seconds a note corresponding to how many vibrations per second will reach the listener who watches the train approach.

Answers by Charles Woolley.

1. No change in vibration rate of string.
2. 45 miles per hr.=66 ft. per sec.
3. 77°F=25°C.
4. Velocity of sound at 25°C=1140 ft. per sec.
5. 3′=wave length.
6. 22 more pulses reach ear at end of a second.
7. 44 more pulses reach ear at end of 2 seconds.
8. 424 vibrations *(answer)*.

Answer by Fred G. Anibal, The University High School, The University of Chicago, Chicago, Ill.

Referring to the solution of problem No. 509 of the Science Questions, SCHOOL SCIENCE AND MATHEMATICS, XXVIII, No. 4 (April, 1928), p. 424.

I find some difficulty in understanding the proposed answer in point 8. The question is, "a note corresponding to how many vibrations per second will reach the listener who watches the train approach?" The answer given is 424 vibrations.

I can agree that the Doppler effect upon the approaching sound will result in twenty-two more vibrations reaching the listener during the first second as indicated in point 6 of the solution. I can also agree that 44 more vibrations will reach the listener in two seconds but not 44 more vibrations per second as perhaps indicated in point 7 of the solution.

It seems to me that the listener will hear a sound having a vibration rate of 22 more per second than the rate of the vibrating string which is vibrating at the rate of 380 per second. The note heard by the listener who watches the train approach will have a frequency of 402 per second at the end of either the first or second second.

Otherwise there would be a constant increase in the rate of vibration of the note as the train approached and the pitch of the note heard by the listener would depend quite as much on the distance of the vibrating string from the listener as upon either the rate of vibration of the string or the speed of the train.

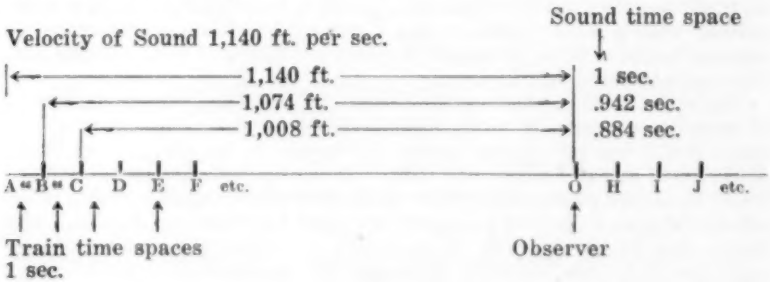
I would appreciate your consideration of the points suggested.

[What do others think about it?—Editor.]

Discussion by R. R. Hatch, Mount Hermon School, Mount Hermon, Mass.

Referring to solutions of problem No. 509 in the June number of SCHOOL SCIENCE AND MATHEMATICS (repeated above), I would like to submit the following:

(1) In the following diagram sound will travel from A to O in one second. The train will travel from A to B in one minute. Sound will travel from B to O in .942 seconds. The observer at O will hear 380 vibrations in .942 seconds or an equivalent of 380/.942, or 403 vibrations per second.



(2) Consider the time and space from B to C. Time for sound to travel from B to O is .942 seconds. Time for sound to travel from C to O is .884 seconds. Elapsed time since train left B until last sound from C reaches O is 1.884 seconds, and period of time in which observer hears 380 vibrations is 1.884—.942 or .942 seconds as before. Therefore in each succeeding second after the train leaves A the observer apparently hears 403 vibrations which is reduced to 380 vib. per sec. the instant the train reaches O.

(3) When the train is receding from O it will reach H in one second. Sound will travel from H back to O in 66/1140 or .058 sec-

onds. The apparent pitch or frequency to the observer will be 380/1.058 or 359 vibrations per second and will remain at that pitch or frequency as long as the train travels at the uniform velocity of 66 feet per second and, so far as the observer is concerned, is in hearing distance.

(4) In like manner, time and space conditions from C to D, D to E, etc., may be considered, and it will be found that the observer hears 380 vibrations in .942 seconds.

Consider also time and space conditions from H to I, I to J, etc., and it will be found that in each division, of time and space, that the observer hears 380 vibrations in 1.058 seconds or an equivalent of 359 vibrations per second.

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HUGE NEW GEYSER IN YELLOWSTONE.

A new geyser of great magnitude, whose volume of water discharge is greater than any other known in Yellowstone National Park since Excelsior Geyser stopped playing in 1888, has broken out in the Fairy Creek section of the Lower Geyser Basin of this great region of thermal phenomena.

The new geyser has been investigated by Dr. Arthur L. Day, director of the Geophysical Laboratory of the Carnegie Institution of Washington, and Dr. Eugene T. Allen, who has been field representative of the geophysical department of the Carnegie Institution here for the past two years.

This huge geyser has a crater of roughly circular form, with diameters of 100 and 120 feet. It erupts twice in 24 hours, and each eruption lasts three hours or longer. The geyser continues to spurt at intervals of from 15 to 20 seconds during its period of eruption, bursting forth from a quiet surface with a loud explosion and throwing a column of water to an average height of 60 to 75 feet, with occasional spurts of 100 feet in height, from a crater eight feet in depth.

The outlet of the geyser crater is four feet wide and during the period of eruption a stream of water eight inches deep flows through it at the speed of 120 feet per minute, giving this geyser by far the greatest water discharge of any in Yellowstone Park. The outlet stream does not receive water from any source other than the geyser. The eruption ceases without warning, and the final outburst seems just as violent as the first. The crater than drains and with the exception of a small fissure ten feet long and three feet wide, elliptical in shape, and several boiling mud springs along the north edge, is entirely dry.

The outer edge of the crater shows a top layer of siliceous sinter about two feet through and under this a wide layer of black sand and hardened clay. The main orifice or fissure through which the principal action comes is lined with sinter.

The action of this geyser is so violent, its eruptions of such magnitude and its intervals of eruption so regular that it bids well to become one of the park's major attractions. It is the largest geyser to be discovered in modern times in the park.

The geyser is yet unnamed and but two parties of explorers have visited it since its discovery. Superintendent Horace M. Albright, Dr. Day and Dr. Allen have made a study of the new phenomenon.—*Science News-Letter*.

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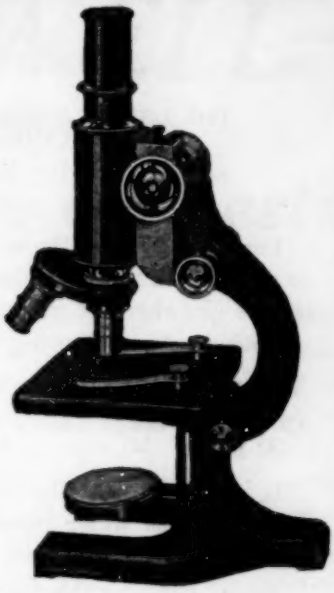

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THE USE OF "NONE OF THESE" IN MULTIPLE-CHOICE QUESTIONS.

By Loyd C. Elliott,

Phoenix High School, Phoenix, Ariz.

For several years the writer has made use of "none of these" as a choice in multiple-choice questions. As he has not noticed its use elsewhere, it might not be amiss to call attention to it.

Consider the following two questions:

All our food comes directly or indirectly from (1) animals; (2) air; (3) plants. .....

All our food comes directly or indirectly from (1) animals; (2) air; (3) plants; (4) none of these. .....

It is evident that the addition of "none of these," as a choice offered, opens wider possibilities than any other single choice could do and so increases the testing value of the question.

Again, consider the following question:

The atomic theory which best explains the lines in the spectrum of an element was developed by and bears the names of (1) Bill Hart; (2) Babe Ruth; (3) Niels Bohr; (4) Charlie Paddock. .....

Most any reader could get the correct choice for this question by the process of elimination. He need not know anything about Niels Bohr and his theory. He would know the others and know it could not be one of them, or if he did not, he could guess that it would not be a Bill, Babe or Charlie. If the question appeared as follows, it would be different:

The atomic theory which best explains the lines in the spectrum of an element was developed by and bears the name of (1) Bill Hart; (2) Babe Ruth; (3) Niels Bohr; (4) Charlie Paddock; (5) none of these. .....

Even after having eliminated the Bills, Babes and Charlies as possibilities, the one taking the test would still have to decide whether it were Niels Bohr or not.

Instructions preceding questions of this type should be about as follows:

Place the number of the one best choice on the line at the end of the question.

"None of these" is offered as a choice and should be chosen if none of the other choices are satisfactory.

Consider the following question:

Present day standardized tests owe their vogue, principally, to the fact that (1) the publishing houses advertise and boost them; (2) prominent educators make money out of them; (3) they are a new idea in tests; (4) they are so much easier for teachers to grade; (5) they are much more accurate than older types of tests. .....

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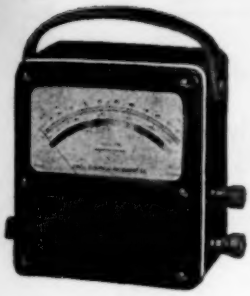

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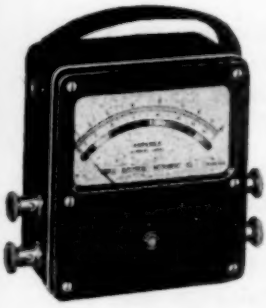

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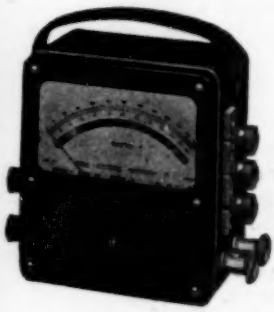

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The mere presence of the fifth choice among the others, is almost a dead give-away. But if the fifth choice is changed to (5) none of these, then the excellent quality of the fifth choice as compared with the others is not present. The question would then be as follows:—

Present day standardized tests owe their vogue, principally, to the fact that (1) the publishing houses advertise and boost them; (2) prominent educators make money out of them; (3) they are a new idea in tests; (4) they are so much easier for teachers to grade; (5) none of these.

The first four choices are about on a par and a student who does not really know why standardized tests are used, would then be more likely to pick one of these choices.

Often times it is desired to construct a test question on a field of knowledge where it is almost impossible to construct a satisfactory correct choice. "None of these" comes in very handily in such cases.

It is hardly needless to mention that it is often difficult to find a sufficient number of choices that are reasonably usable. Here is one that is ready-made for almost any multiple-choice question, and does not take the time to construct that is taken by the ones that must be tailor-made to fit a particular question.

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GENERAL SESSIONS

Friday, November 30, 1928

REGISTRATION—Reynold's Club 8:15-9:15 a. m.
General Session—Mandel Hall

ORGAN RECITAL—9:15-9:30.
JAMES W. HOGE, *Organist for the Laboratory Schools, The University of Chicago.*

ADDRESS OF WELCOME—PROF. ELLIOT R. DOWNING, *The University of Chicago.*

RESPONSE FOR THE ASSOCIATION, L. E. HILDEBRAND, *New Trier High School, Winnetka, Ill.*

PRELIMINARY REPORT: The Purposes and Plans of the Incorporated Association, ADA L. WECKEL, *Member of the Board of Directors.*

ADDRESS: PROF. OTIS W. CALDWELL, *Columbia University*, Subject: Some of the Next Steps in Science Teaching.

ADDRESS: PROF. LOUIS C. KARPINSKI, *University of Michigan*, Subject: Mathematics and the Progress of the Sciences.

Friday, November 30, 6:45 P. M.

Annual Dinner. IDA NOYES HALL.

Illustrated Lecture—JOHN MILLS, *Director of Publications, Bell Telephone Laboratories, New York City.* Subject: Electrical Eyes and Their Use in Communication.

Saturday, December 1, 8:30 A. M.

Annual Business Meeting. 8:30 A. M.

General Session, 9:15 A. M., LEON MANDEL HALL.

ADDRESS: PROF. W. D. HARKINS, *The University of Chicago*, Subject: The Revolution in Chemistry.

ADDRESS: JEROME LEDERER, M. E., *President of Aerotech, Inc.*, Subject: Elementary Aerodynamics.

ADDRESS: DR. W. T. BOVIE, *Northwestern University Medical School*, Subject: The Stuff We Are Made of Considered as a Basis for Individuality.

SECTIONAL MEETINGS

Friday, November 30, 1:30 P. M.

BIOLOGY

Botany Building—Room 13

The So-called Educational Biology Course.
Prof. Otis W. Caldwell, Columbia University.

Interesting Recent Researches.
Dr. A. J. Carlson, University of Chicago, Chairman, Department of Physiology.

Mammals of North America.
B. G. Grant, Field Museum of Natural History, Chicago, Illinois.

Field Trips in Biology.
Dr. Alfred Kinsey, Indiana University.

What Mushroom Is That?
V. O. Graham, Prin. Barry School, Chicago.

A trip to Field Museum on Saturday afternoon will be arranged for by the chairman if a sufficient number in the group desire it. The place and time of meeting will be announced by the chairman.

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Transmutation of Metals—Historical Treatment.
Dr. W. L. Badger, Prof. of Engineering Chemistry, University of Michigan.
Humanizing the Teaching of Chemistry in High School.
Paul G. Edwards, Crane Technical High School, Chicago, Illinois.
General Discussion.
Remarks by the Chairman, Dr. A. F. McLeod.

GENERAL SCIENCE

Mandel Hall

The Science of the Elementary School and Its Relation to the Science of the Junior High School.
Dr. Gerald S. Craig, Teachers College, Columbia University.
Tests in General Science—Who, What, Why, When, Where, How?
Prof. Harry A. Cunningham, Kent State Normal College, Kent, Ohio.
Newer Teaching Procedures in High School Science with Special Reference to General Science.
Dr. Ralph K. Watkins, College of Education, University of Missouri.
Supplementary Aids in Teaching General Science.
Prof. Ellis C. Persing, School of Education, Western Reserve University, Cleveland, Ohio.
Some First Hand Information Concerning Science Clubs.
Dr. H. A. Webb, George Peabody College for Teachers, Nashville, Tennessee.

GEOGRAPHY

Rosenwald Building—Room 2.

Contract Method in High School Commercial Geography.
H. O. Lathrop, State Normal School, Whitewater, Wis.
Discussion, Led by
Thomas A. Finley, Austin High School, Chicago, Ill.
Teacher Training Thru Field Work in Geography.
Robert G. Buzzard, Illinois State Normal University, Normal, Illinois.
General Discussion.
Illustrated Lecture: "India, A Land With Too Many People."
Wellington D. Jones, University of Chicago.
General Discussion.

MATHEMATICS

Little Theatre, Reynolds Club

The Drift in Junior High School Mathematics.
Mary A. Potter, Racine High School, Racine, Wis.
Discussion led by Martha Hildebrandt, Proviso High School, Maywood, Illinois.
Worthwhile Literature in the History of Mathematics Desirable for the Teacher in Secondary Schools.
Prof. Louis C. Karpinski, University of Michigan, Ann Arbor, Michigan.
Discussion led by Jos. A. Nyberg, Hyde Park High School, Chicago, Illinois.
Mathematics in Industry.
Clarence J. Leonard, Cass Technical High School, Detroit, Michigan.
Discussion led by Marx Holt, Prin. Seward School, Chicago, Illinois.

PHYSICS

Physics Building—Room 32

The Teaching of Archimedes' Principle and Its Applications.
Major G. B. Eisenhard, Culver Military Academy, Culver, Indiana.
Research in Acoustics.
Dr. Paul E. Sabine, Riverbank Laboratories, Geneva, Illinois.
Teaching the Principles and Applications of Electromagnetism with Concrete Materials.
M. J. W. Phillips, High School, West Allis, Wisconsin.
Teaching the Induced Current.
A. W. Hurd, School of Education, University of Minnesota, Minn.
An Adaptation of the Unit Plan to the Teaching of Physics in a Large City High School.
A. W. Augur, Tilden Technical High School, Chicago, Illinois.

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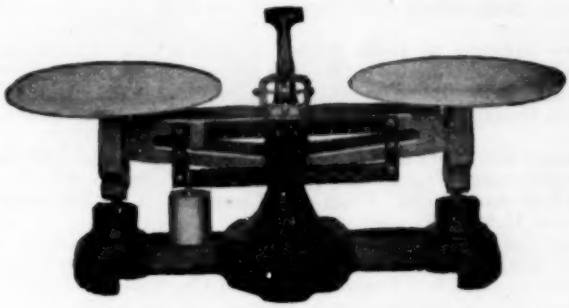

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BOOKS RECEIVED.

Plane Geometry by Joseph P. McCormack, Head of the Department of Mathematics in Theodore Roosevelt High School, New York City. Cloth. Pages xii+371. 12.5x18.5 cm. 1928. D. Appleton and Company, 35 West 32nd Street, New York. Price $1.40.

College Chemistry by Neil E. Gordon, Professor of Chemical Education, Johns Hopkins University. Cloth. Pages ix+516. 13.5x20 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $2.96.

New Analytic Geometry by Percey F. Smith, Professor of Mathematics in the Sheffield Scientific School of Yale University, Arthur Sullivan Gale, Professor of Mathematics in the University of Rochester and John Haven Neelley, Associate Professor of Mathematics in the Carnegie Institute of Technology. Revised Edition. Cloth. Pages x+326. 12.5x18.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.00.

Laboratory Manual of High School Chemistry by George Howard Bruce, Department of Chemistry, Horace Mann School for Boys, Teachers College, Columbia University. Cloth. Pages ix+101. 13x18.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price 76 cents.

The Engineer, His Work and His Education by Robert Lemuel Sackett, Dean of Engineering, The Pennsylvania State College. Cloth. Pages vii+196. 13x20 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $1.40.

Elementary Calculus by Frederick S. Woods and Frederick H. Bailey, Professors of Mathematics in the Massachusetts Institute of Technology. Revised Edition. Cloth. Pages +385. 13.5x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $3.00.

The Development of Children's Number Ideas in The Primary Grades by William A. Brownell, Assistant Professor of Educational Psychology, University of Michigan. Paper. Pages xiii+241. 15.5x23.5 cm. 1928. The University of Chicago, Chicago, Ill.

Geology and Mineral Resources of the Herscher Quadrangle by L. F. Athy. Bulletin No. 55. State Geological Survey. Paper. 120 pages. 17x25.5 cm. 1928.

A Textbook of General Botany by Gilbert M. Smith, Standford University, James B. Overton, Edward M. Gilbert, Rollin H. Denniston, George D. Bryan and Charles E. Allen, University of Wisconsin. Revised Edition. Cloth. Pages x—359. 13.5x21.5 cm. 1928. The Macmillan Company, New York.

Algebra for Secondary Schools by Stephen Emery and Eva E. Jeffs, Erasmus Hall High School, Brooklyn, New York. Cloth. Pages xii—626. 13x18.5 cm. 1928. D. Van Nostrand Company, Inc., Eight Warren Street. New York. Price $1.85.

BOOK REVIEWS.

High School Trigonometry with Tables, by David Raymond Curtiss and Elton James Moulton, Professors of Mathematics, Northwestern University. Pages x+216+94. 14.5x20.3 cm. D. C. Heath and Co. Boston. Price $1.48.

The authors have written a wordy text to obviate the necessity of lecturing on the part of the teacher. They have made it flexible so as to meet the needs of various classes of students. Thus, the book may be used for a survey course of fifteen lessons; for two thirty lesson courses; or, for a course of fifty, or more, lessons.

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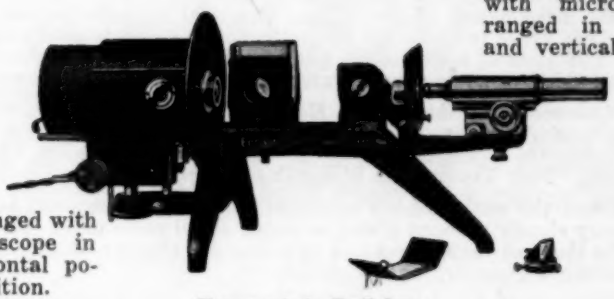

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Trigonometry, by Ernst R. Breslich, Assistant Professor of the Teaching of Mathematics, The College of Education, The University of Chicago, and Charles A. Stone, Instructor of Mathematics in the University High School, The University of Chicago, and Chairman of the Department of Mathematics, The Central Y. M. C. A. College of Arts and Sciences, Chicago. Pp. xii+176+122. 14x20 cm. 1928. Chicago. The University of Chicago Press. Price $1.85.

The authors have made the attempt to present trigonometry in a simple concrete manner that will appeal to students of the early secondary school. All the essentials of the subject are presented, however, together with such topics as Demoivre's Formula, The Trigonometric Series, Complex Numbers, Hyperbolic Functions, etc. The inductive method is employed to develop new concepts. Definitions follow, rather than precede, the introduction of new ideas. Practical applications are presented early in order to make the subject concrete and interesting to the student. The ideas of approximate numbers and the degree of precision to be expected in a concrete situation are given attention. J. M. Kinney.

Plane Trigonometry, by Arthur M. Harding, Professor of Mathematics, University of Arkansas, and George W. Mulless, Professor of Mathematics, Barnard College, Columbia University. Pp. vi+118. 13x20 cm. 1928. New York. The Macmillan Company.

In this text the authors have attempted to present the essentials of trigonometry clearly without giving so much detail as to make the book bulky. To this end they present an introductory chapter which bridges the gap between geometry and trigonometry.

The definitions of the trigonometric functions are presented first in the general form based on the rectangular coordinate system. The solution of the general triangle immediately follows that of the right triangle. J. M. Kinney.

Analytic Geometry, by R. L. Borger, Professor of Mathematics, Ohio University. Pp. xii+334. 13.5x19 cm. 1928. New York. McGraw-Hill Book Company. Price $2.50.

The author's aim is to present the subject of analytic geometry in such a way that the student will form the habit of looking at a problem from both the geometric and algebraic view points. This double point of view is stressed especially in the second chapter in which Peano's geometric method of constructing curves in cartesian coordinates is given together with the polar and parametric forms. J. M. Kinney.

Laboratory Glass Blowing, by Francis C. Frary, Director of Research, Aluminum Company of America, Cyril S. Taylor, Physical Chemist, Aluminum Company of America and Junius David Edwards, Assistant Director of Research, Aluminum Company of America. Second Edition revised and enlarged. Cloth. Pages x+116. 14x20.5 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York.

This book is a revision of the senior author's "Laboratory Manual of Glass Blowing" published in 1914. The most important additions to the former manual consist in directions for manipulating Pyrex glass. The first chapter describes the principal characteristics of the various types of laboratory glass and gives some general directions relative to kinds of apparatus desirable for glass blowing. Chapter II describes the general operations such as cleaning the glass, cutting and bending glass tubes, drawing out tubes, constricting, flanging, etc. The remainder of the book consists of a set of exercises for which specific definite directions are given. In these directions "the aim has been to describe each operation in such detail that a beginner can follow the process without help and, with practice, attain satisfactory results." The authors recognize, however, that like any process of skill much advantage is gained and time saved by seeing the processes correctly performed. It is a very valuable little book for anyone wanting to acquire skill in manipulating glass in the laboratory and it should be in every physics library. G. W. W.

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A First Course in Physics for Colleges, by Robert Andrews Millikan, Ph.D., Sc.D., Director of the Norman Bridge Laboratory of Physics, Pasadena, California, Henry Gordon Gale, Ph.D., Professor of Physics in The University of Chicago, and Charles William Edwards, M. S., Professor of Physics in Duke University. Cloth. Pages xiii+676+xlii. 13.5x 20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $3.72.

This book, which is really a college edition of the high school text which appeared under the name "A First Course in Physics" by Professors Millikan and Gale, may be characterized as a book designed especially for students who find physics a very difficult subject. The general plan of treatment is to sub-divide the chapters into smaller divisions consisting of a few pages of theory illuminated by many good diagrams and clarified by illustrative examples with complete solutions. These are followed by a short list of problems for solution. Each chapter is concluded by a list of test questions. Any chapter selected at random will illustrate this plan, e. g. Chapter VI entitled "Pressure of Liquids at Rest," is sixteen pages long and has three subdivisions: (1) Liquid pressure beneath a free surface consisting of four sections of theory, five diagrams, two solved problems and thirteen problems for solution; (2) Pascal's Law, consisting of five theory sections, four diagrams, four full page illustrations, three solved problems and eight problems for solution; (3) The Principle of Archimedes, consisting of seven theory sections, eight diagrams, two full page illustrations, four solved problems and thirteen problems for solution. Seventeen test questions on the chapter follow.

Attention is directed to the human interest phase of the subject by including numerous biographical sketches, half-tones and brief descriptions of the masterpieces of engineering, explanations of classical experiments and of interesting devices in common use. Throughout the text the authors have used italics to emphasize important words and to give concise statements of definitions and principles. The problems, questions, and descriptions of experiments are put in smaller type. The diagrams are clear and completely labeled. The appendixes contain over a hundred additional problems listed by chapters, fifteen tables of constants, and answers to the problems.

The text deserves to receive the serious consideration of all teachers of classes of general physics for non-engineering students. The mathematical aspects of the subject have been reduced to high school algebra, geometry, and very rare use of trigonometry. High school teachers will want the book for reference because it contains such excellent discussions of many of the interesting experiments and theories that are so frequently mentioned in current literature, and because it furnishes a wealth of material for superior high school students. G. W. W.

Statistical Methods for Students in Education, by Karl J. Holzinger, Associate Professor of Education, The University of Chicago. Cloth. Pages viii+372. 13.5x20.5 cm. 1928. Ginn & Company, 15 Ashburton Place, Boston. Price $3.60.

Altho a number of books dealing with the application of statistical methods in education have appeared in recent years practically none of them have made adequate provision for the limited mathematical training of the majority of students in education. One of the chief characteristics of this book is that it supplements the preparation of the student by giving fairly complete discussions of the mathematical topics most often used in the course. A good example of this is the eighteen-page chapter on logarithms which gives a theory discussion, the solution of several typical problems, and a four-place table. Throughout the book the author has made use of tables of data selected from educational investigations for showing the correct methods of tabulation and treatment. The book is well adapted for use in classes pursuing the study for periods of for from three to six months. G. W. W.

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Coal and the Coal Mines, by Homer Greene. Revised Edition. Illustrations. Cloth. 225 pages. 11x17.5 cm. 1928. Houghton Mifflin Company, Boston, Mass. Price $1.24.

This book was written for the purpose of giving the reader a general idea of the coal mining industry. The author has had in mind its use as a supplement to the study of elementary physical and social science as well as its interest to readers out of school. He has selected the most important facts relative to the industry and has condensed them into an interesting account. He tells about the formation of coal, its composition, how the coal beds lie, how it is mined and how it was discovered and introduced as a fuel. His descriptions of the mines and the conditions of the miners as they carry on their daily work exposed to the dangers of fire damp, falling roofs and rushing water are vivid but portray typical conditions. A glossary of mining terms is appended for the convenience of the reader. L. C. W.

The number of books received recently for review has so far exceeded the space available for reviews that it is necessary this month to pass over a number of books by describing each in a sentence or two.

Algebra Review Exercises by Josiah Bartlett, Gilman Country School, George W. Creelman, Hotchkiss School, Cecil A. Ewing, Tome School, Ernest E. Rich, Lawrenceville School, George R. Wilson, Taft School. Cloth. Pages vi+151. 12x18.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $1.00.

This book consists of exercises by topics, cumulative reviews and typical examinations, just the book for students preparing for special examinations.

Drill Problems in Vocational Mathematics by William H. Dooley, Principal of the Textile High School, New York City. Cloth. Pages ix+195. 12.5x18.5 cm. 1928. D. C. Heath and Company, New York. Price $1.40.

This is a supplement to the author's Vocational Mathematics. It is made up of over thirteen hundred practical problems which weld the mathematical theory to the mathematics of the shop, experimental laboratory, and business office. Teachers unfamiliar with industrial practice will find this book very valuable.

Fun with Figures by A. Frederick Collins. Cloth. Pages xvi+253. 12.5x19 cm. 1928. D. Appleton and Company, New York. Price $2.00.

Just what the title indicates: figure tricks, magic squares, mathematical paradoxes, book-keeping blunders, etc.; entertaining, amusing, instructive.

Problem Exercises for High School Teachers, Preliminary Edition by Douglas Waples in collaboration with W. C. Reavis, The University of Chicago and others. Cloth. Pages ix+99. 15x23.5 cm. 1928. The University of Chicago Press, Chicago, Ill. Price $1.00.

This book is a collection of six groups of problem situations prepared for the use of instructors of courses in general methods and for school principals and administrators. Each group consists of ten typical classroom situations each of which is followed by five ways of meeting it. The test consists in selecting the best and the least satfsfactory proceedure

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Success in Teaching Arithmetic, A Teacher's Manual to Accompany The New Everyday Arithmetic by Franklin S. Hoyt and Harriet E. Peet. Cloth. Pages v+320. 12.5x18.5 cm. 1928. Houghton Mifflin Company, New York. Price 92 cents.

A book for teachers of arithmetic in all grades. It points out the objectives, assists in diagnosis, shows how to make the arithmetic work interesting and how to achieve results. Every arithmetic teacher should have a copy.

Fundamentals in Visual Instruction by William H. Johnson, M.A., Ph.D. Cloth. 104 pages. 13.5x21.5 cm. 1927. The Educational Screen, Inc., Chicago, Illinois.

A manual for teachers using visual instruction methods. It discusses the general principles of visual instruction, the use of visual aids in various subjects, and the use and care of equipment for visual instruction.

Physics Review Book by Arthur H. Killen, Flushing High School, Flushing, L. I., N. Y. Cloth. Pages iv+283. 13x19 cm. 1928. Oxford Book Company, New York. Price, paper 68 cents and cloth 80 cents.

A complete review of elementary physics, well illustrated and covers all phases of physics subject matter: theory, laws, formula, problem solving, experiments, examination questions. It is up-to-date, good binding, convenient size—an unusual review book.

Teachers' Manual to Accompany New Civic Biology by George W. Hunter, Ph.D., Adjunct Professor of Biological Sciences, Pomona College, Claremont, Calif. Cloth. Pages v+105. 12x18.5 cm. 1927. American Book Company, Chicago, Ill. Price 60 cents.

This book contains a wealth of helps for biology teachers, including suggestions for organizing the work, for applying effective methods of teaching, for collecting and preparing materials and gives a complete outline by chapters of the author's New Civic Biology. It is especially helpful to inexperienced teachers.

Laboratory Manual of High School Chemistry by George Howard Bruce, Department of Chemistry, Horace Mann School for Boys, Teachers College, Columbia University. Cloth. Pages ix+101. 13x18.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price 76 cents.

This manual consists of sixty experiments. Each experiment lists the materials required, gives in numbered paragraphs brief directions for each step and asks the student definite questions on each step. The manual can be obtained in either bound or loose-leaf form.

The Frog, A Laboratory Guide by Waldo Shumway, Ph.D., Associate Professor of Zoology, University of Illinois. Cloth. Pages viii+67. 12.5x18.5 cm. 1928. The Macmillan Company, New York.

This manual for the zoology laboratory follows the plan of telling the student what to look for. It is made up of ten sections which include 342 numbered steps. It is provided with both a table of contents and an index.

A Guide to the Wild Flowers, by Norman Taylor, Curator, Brooklyn Botanic Garden. Cloth. Pages x+357. 12x18.5 cm. 1928. Greenberg, Publisher, Inc., 112 East 19th St., New York. Price $3.00.

This is a compact but concise and practical guide to the wild flowers of North America east of the Mississippi and north of Virginia. It describes more than 1200 species and contains over 500 drawings. The numbering method is simple and ingenious. It is a popular rather than a technical guide. The Finding List and Picture Flossary are valuable features.

Flower Families and Ancestors by Frederic E. Clements, Ph.D., Carnegie Institution of Washington and Edith S. Clements, Ph.D., Carnegie Institution of Washington. Cloth. Pages x+156. 15x22.5 cm. 1928. The H. W. Wilson Company, New York. Price $2.40.

For the plant-lover this is a delightful book in a most exquisite binding. It was "written in the hope of making the study of flowering plants both simple and attractive to beginners of all ages." The book is well-illustrated by a flower chart in color and sixty-four illustrations each of which consists of several separate but related parts. It should be in all school and public libraries, and will be a highly appreciated gift for your flower-loving friend.

G. W. W.